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Metallurgical and Chemical Engineering

An Incorporation of

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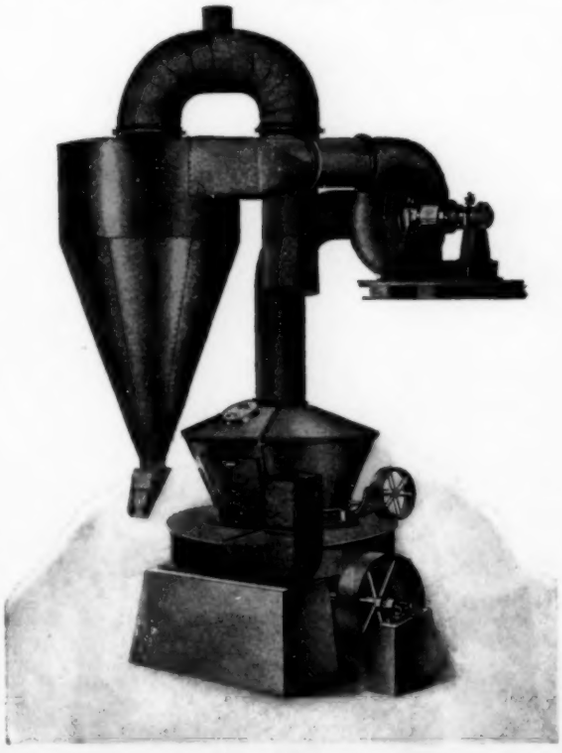

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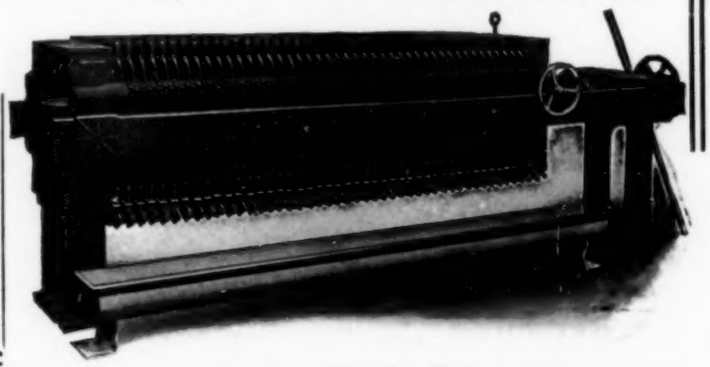

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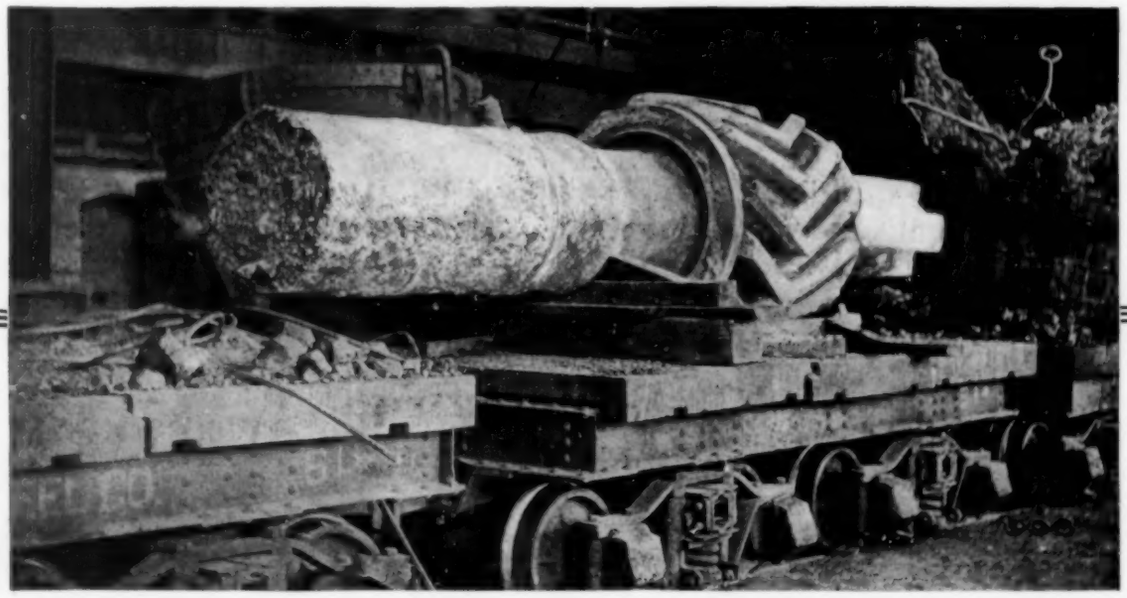

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The Electrochemical Publishing Company, publisher of this journal, was formed ten years ago with the co-operation and support of the McGraw Publishing Company. All of the stock of the Electrochemical Publishing Company has now been acquired by the McGraw Publishing Company, which will, hereafter, be the publisher of Metallurgical and Chemical Engineering. The stockholders of the Electrochemical Publishing Company have become stockholders of the McGraw Publishing Company. There will be no change in the editorial and business staff, or in the management, except that the staff will be able to call more freely than ever upon the professional and business resources of the McGraw Publishing Company.

I sincerely hope that this step, which was taken with the hearty and unanimous consent of the minority stockholders of the Electrochemical Publishing Company, will enable this journal to fulfill in future still more energetically its mission in technical journalism and to remain true to the ideals for which it has stood these ten years. To this end I pledge my full support.

James H. McGraw.

General Business Conditions and the Metal Markets in 1912.

The expansion in the metal markets in the past year has exceeded the expectations of many and the hopes of a few. For, considered as far as output and prices go, 1912 has been a banner year in the metallurgical industry. Indeed, in the past two months it has been pushed to the extreme in making prompt deliveries in certain lines. As the metal markets are such a sure index of the growth of the business of the United States, in considering the past general aspects of the metal business, due regard must be paid to those fundamental commercial prime-movers, the crops and the psychological atmosphere. So, it must be clearly held in mind that all crops save cotton were in 1911 considerably below the average and that in 1912 all the crops were considerably above the average. In the ultimate analysis, the price of foodstuffs is the chief immediate factor in industrial life. It can be laid down as a fact, therefore, that the halting tendency manifest a year ago had its main cause in the poor condition of agriculture, and that the rush of business in the latter part of 1912 was due to the assurance that the farmer had been bounteously aided by Dame Nature and that there was a surplus of food products. This in point of fact counteracted the effects of the presidential campaign.

At the same time man cannot live by bread alone, and the profound influence of what people think and feel preponderates over the direct acting stomachic forces—potent as they are in their own sphere. The general mental and spiritual food that was consumed in America contained certain good elements and certain poisonous elements. Yellow journals and several of the magazines generate in one

a feeling of horror and disgust. Yet there are many millions of calm, sensible and sober men and women who form the real opinions of society and on whose mental balance and on whose self-control our entire national welfare and life depends. These people are the substance of America. The others are the excrescences. Now, life is derived from sentient intelligence and from real sources of subjective power.

With these conceptions in mind, let us turn to specific events of the past year. At first there was a braking effect on the wheels of industry because of the poor crops of 1911, and due to the usual apprehension of a presidential year. However, copper and spelter started to move fast and strong in the early spring. The great expansion in the electrical trade resulted in an enormous consumption of copper and as we have said before there cannot long be in this age of electricity too much copper.

For a considerable period in recent years, business has been dominated by a spirit of rational conservatism. This spirit has shown faith in the future and practically has exercised energy in present endeavor. Without this we would now be in a perilous condition. Since there was a good foundation of conservatism, when once the good crops of 1912 were harvested, something that approached a boom arose. The election over, a scarcity of labor and supplies was marked. At the same time the Balkan war came on and caused a general restriction of credit in Europe. Now, slowly and surely, the inhibiting forces manifest themselves—in traces only, to be sure, but certainly in a slight tendency to quiet. Labor and political troubles, phenomena closely connected with all industrial life, were manifest throughout the year. The fear of them is an inhibiting force. All such forces are much needed checks on extravagance and the actions of the unintelligent. An individual case now is the query of the business man, "Why should I build now when labor and capital and supplies are scarce, high, and dear?" No observer can deny that this is the case and no reasoning person can refuse to admit that a negative answer is the logical one.

Another inhibiting force is that large sums of money have been sunk in enterprises of sure merit, such as the Panama canal, whose return to capital must needs be long delayed. This state of affairs is not so pronounced as in 1905-7, but it is nevertheless a check to expansion. It would seem inevitable and natural to expect for several reasons soon a holding off in the demand for metals and a market much more favorable to the consumer. A feeling of uncertainty begets caution, for the emotion of doubt in an intelligent person becomes volitional caution.

Let us look at this phase broadly and consider the varying conditions of mental unrest that is so marked in the civilized world. Let us also remember the great ease and accuracy with which intelligence nowadays can be transmitted. From both it follows that we are to have short periods of expansion followed by equally short periods of retrenchment for the next few years as has been the case for the past five years. This is a healthy state of affairs, for it shows that moral forces are working quickly and surely in the industrial world.

Now the greatest fault with America is the widespread extravagance starting in with the so-called upper classes that ought to know better but do not, and progressing thence by social migratory imitation to the working classes. This causes more trouble than all the wars, more than all vice, for it is fundamental in its perverse character. Fortunately or unfortunately, according to the viewpoint, this country is a young giant on whom excesses seem to make little effect. But the time has come for the country to put away childish things and to become a strong man under control.

This same extravagance engenders envy and is so the cause of political and social unrest. We can be sure that it makes for destruction, and, if it were not for the fact that it is not universal and that the great law of compensation acts against its increase, things would surely be pretty bad. Now, all the waste of extravagance prevents a larger healthy growth in the metal business.

Besides these far-reaching causes, there is, of course, the uncertainty that the coming tariff legislation brings. There seems to be a feeling that this country could profitably import some of its labor "in cans and boxes" and that the best way to stop labor troubles is by a gradual lowering of the tariff and that so immigration will be lessened and the nation will have time to absorb and assimilate the vast mass of immigrants already here so that we can reach a condition of social equilibrium. Moderate action in this way will be of great benefit, but any running amuck will distil over into business unrest.

After all has been said, however, we have certain facts to count on and to recite. The pig-iron production has reached the greatest annual total and the greatest daily average in its history. This is likewise true of steel. Prices of both have averaged fair.

Copper and spelter have made the greatest production as yet recorded and in the face of this prices have advanced. Lead has not made as satisfactory a showing. Apparently the copper business has not yet felt the incoming of several large producers. As the consumption both abroad and in this country has been enormous, it has been easy to keep copper prices at a good level. Whether this has been caused by the centralized control is, of course, a question. Undoubtedly the consumption has been so strong that such a process as that called "pegging" would have been easy. But, be that as it may be, 12.50 cents is altogether too low a price to be paid for the "red metal" if capital is to be attracted into the business at a rate needed for the demands of an electrical age. It is sure that new mines will not be developed unless the price of the metal is so high to make profits large enough to justify the risk. Still, all things considered, copper looks strong though much depends on European demand.

Spelter has likewise undergone an enormous expansion in the face of an increasing price. For the last six months spelter has averaged 7 cents per pound or over at New York, and has reached a price of 7.90 cents, thereby breaking all records. The zinc smelter has reaped a rich harvest, but as the prices of metal have been extremely high, prices for ore have been also high and the zinc mining companies have not suffered. Joplin, while still the most prominent ore center, does not hold the prominent place that it did formerly, and we have seen in 1912 Butte, the great copper district, becoming a producer of zinc ore on a large and serious scale.

For many reasons it can be concluded that there is present a spirit of caution both among producers and consumers of metal that is bound to check any decided increase of further expansion. But it can also be concluded that after this steadying influence has had its work, the fact that foodstuffs will be cheapened inevitably is bound to enlarge the purchasing power of the industrial classes. There will thus be a larger margin that can be spent otherwise and in the early spring we should see a stiffening of prices. There are born some good judges of metal markets, who believe that the latter tendency will be found to be so strong as to obliterate the evidences of the first. Later in the year, when the question of new crops comes up, there is another restricting factor that will come into play. So, eliminating the effect of chance events and allowing for the uncertainties of politics, the next year has a good outlook.

Last January we based our conservative views on the poor crops of 1911. Events have shown that our views were too conservative . This year our views may prove too optimistic. But, with much good feeling among sensible people of all classes and with the full dinner-pail that nature has provided the country, we reasonably expect that the metallurgical industry will receive the good treatment that it deserves for converting potential mineral wealth into the actual wealth of refined metals, which latter are modern civilization's prime requisites.

A Noteworthy Year in Iron and Steel.

The year which has passed into history was a most noteworthy one in the iron and steel industry, made so by commercial conditions as to demand which were not remarkable in themselves but which disclosed conditions in the industry deserving of special mention and in some respects of very careful thought.

There has been, as all know, a wonderful "revival" in the industry. This revival has not been produced by a spectacular increase in demand. In November, 1911, mills were making up rolling schedules, in many cases, from turn to turn, and were able to ship most products in from one day to one week after the receipt of specifications, while prices were dropping to their lowest point, as to finished steel since early in 1899 and as to pig iron since 1904. At the close of 1912 pig iron had advanced $4 a ton and finished steel products an average of $6.50 to $7 per net ton, while the mills had actual specifications on books for three months of full operation, and contract business for from three to five months additional operation.

This was a wonderful reversal in the commercial position of the industry, yet the interesting fact is that in November, 1911, production was at a rate fully 75 per cent. as great as the rate in the three closing months of 1912. Consumption appears to have increased by one-third, which is not much, but there is reason to suspect that the consumption in ordinary channels has not really increased as much as that. In November, 1911, exports were at the rate of 2,250,000 tons per annum, and in the closing months of 1912 at the rate of 3,000,000 tons, an increase of 750,000 tons. Comparing the same periods there was an increase in the rate of iron and steel consumption by car shops of fully 1,000,000 tons per annum, and a considerable increase in the consumption of other railroad material. It seems fair to estimate that outside of the increases in exports and the increases in railroad consumption there has not been an increase in general demand of more than about 20 per cent at the outside. Of course, it must be recognized that the action of buyers in placing contracts far ahead, and in specifying material which cannot be delivered in less than three months is purely a result of the sold-up condition of the mills, and not a product of their own commercial position. In the condition in which these consumers found themselves in November, 1911, they would have contracted and specified just as far ahead had they observed a condition of the mills being behind in deliveries as they have been of late. Specifications accumulate when mills are slow in delivery and thus produce greater slowness until the movement plays itself out. That is the course in a free market, thoroughly "unscientific," perhaps, but perfectly natural.

Much will be said in the current trade reviews of what caused this so-called wonderful revival in the iron and steel industry, and what further will come of it. With a free market, where what occurs is largely natural and inevitable, it avails little to discuss these points. Of much more interest, and of vastly more profit, is it to dwell upon the conditions in the alignment of the iron and steel industry which the developments of 1912 have disclosed.

First and foremost is the peculiar condition disclosed as to the supply of coke. We are familiar with lists of the beehive ovens of the country and statements as to the capacity of the by-product ovens. We have also seen compilations of the total blast furnace capacity of the country. Such compilations have a probable error which might be negligible when the compilation is used for some purposes, but which is altogether too great to make it worth while to devote time to a comparison of the relative capacities for coke-making and pig-iron production, equal to coke consumption. Far more conclusive is a study of commercial conditions, of market results, for there the conclusions are written in actual money, and "money talks."

From the low point, about January 1, 1912, pig iron in northern markets advanced an average of $4 per ton. Contracts for Connellsville coke for the first half of 1912 were made in November, 1911, per net ton at ovens, at $1.55 and $1.60, and in December at $1.65. At the close of 1912 the same coke was held, for the first half of 1913, at $3.50, an advance equal to fully $2 in the cost of making a ton of pig iron. Lake Superior iron ore was advanced, for the season of 1913, 65 cents on Bessemer and 55 cents on non-Bessemer ores, equal to about $1 in the cost of making pig iron.

The major operation is that of making pig iron, yet only one-fourth of the advance in pig iron stays with the blast furnace, which is an altogether unreasonable commercial movement. There are no coke ovens idle because there are not prospective customers for the coke, but there are many idle blast furnaces, with a pig-iron market awaiting them, and idle because they cannot secure coke at a suitable price.

The coke-making capacity of the Connellsville region is substantially the same as it was in 1906, six years ago. Meanwhile the blast-furnace capacity of the country has been increased almost one-half, *i.e.* give each existing blast furnace the supply of raw materials and the market for pig iron, which existed in 1906, and about one-half more pig iron could be made. The commercial capacity is not

one-half greater, simply because the raw materials are not available, and market prices for pig iron are lower. Blast furnaces have been built in the past six years to the extent of about 9,000,000 tons annual pig-iron capacity, requiring 10,000,000 tons of coke and the coke supply has not been increased by anything like that amount.

Again, depending upon the market movement to disclose physical condition, one finds that billets and sheet bars have advanced $10 per gross ton in this upward movement of about a year's duration, while the finished steel products made from them have advanced somewhat less than $7 per net ton. A reasonable alignment would be that the finished product, the thing of greater value, should advance more per ton than the unfinished material. As outlined at some length in our current iron and steel market review, the condition arises largely from the fact that finishing capacity is usually in excess of steel-making capacity, through the expectation of builders that all branches of the finishing trade will not usually be fully employed throughout, the further fact that the transition from Bessemer to open-hearth steel has left Bessemer capacity unemployed when the attendant finishing capacity is equally available for rolling open-hearth steel, and finally the fact that there is a large demand for rails, while many of the billet and sheet bar mills are convertible into rail mills.

Obviously there is required a greater expansion in open-hearth steel-making capacity. The rate of new construction in this direction has been much less in the past two years than in immediately preceding years. Of the Bessemer capacity thrown idle by the change in demand towards open-hearth steel, there has been considerable utilization by adoption of the duplex process, but the developments in the building of pure open-hearth departments and the constitution of duplex departments has not been as rapid as the market movements show it should have been. That is, perhaps, not all of the story. The whole industry may be shaken any day by finding itself under the necessity of adopting a method of producing sound ingots, requiring little if any cropping. Comparison of steel ingot and rolled-steel production statistics show that there is being produced to-day in the steel works and steel rolling mills about 8,000,000 tons per annum of new steel scrap, practically all of which finds its way into open-hearth steel works, but a large part of which would suddenly disappear should a method of producing sound ingots be adopted. A large premium upon the non-scrap processes, like the duplex, would instantly be written, and those who had early adopted such processes could count themselves most fortunate.

This much for two clear facts which the movements in the year 1912 have disclosed, in that certain departments of the industry have not developed as they should. Perhaps it would be true to say that the whole industry has not grown as rapidly as it should have done. Five years ago—and the point is that many in the trade do not realize that it is as long as five years ago—men were saying that the industry was overgrown and that a period of years would be required for demand to grow up to capacity. For five years this demand has had a chance to grow. For two or three years following 1907, the year which saw that memorable slump in demand, capacity grew somewhat rapidly, but in the past two years it has grown but slowly. The country is now making pig iron at the rate of only between 32,000,000 and 33,000,000 tons per annum, although apparently the existing capacity is strained, but in 1906 it actually produced 25,307,191 tons, and from the rate of growth which was shown by the increase from 1,205,663 tons in 1866 to 5,683,329 tons in 1886 anad then to 25,307,191 tons in 1906, the tonnage for 1912 can be extrapolated as 40,000,000 tons, instead of the 29,600,000 tons estimated as the actual production of 1912 and the rate at the close of the year of only slightly more than 32,000,000 tons.

Metallurgy of Gold and Silver in 1912.

The past year was marked by many advances in the treatment of gold and silver ores. As might be expected, cyanidation held the premier place among processes, and strengthened its position as the prevalent method of gold recovery. No mention has been made of an attempt to revive chlorination, although one company in Utah is reported to have adopted a process in which a chloridizing roast is an important feature. Nothing of special importance has occurred in the way of electrolytic amalgamation, in spite of the fact that the records of the Patent Office indicate activity among inventors in this branch of metallurgy. It appears that there may be a legitimate field of operation for such processes, and we may look for tangible results from some of the proposals that have been made by competent engineers.

In the domain of amalgamation interest must center naturally in the radical departure at the Nipissin high-grade mill, in the Cobalt district, Ontario, Canada, where high-grade silver ore is given a combination treatment by amalgamation and cyanidation. Ore containing 2500 oz. silver per ton is ground to 20-mesh size and treated in a tube mill with 4 tons of mercury, 2 tons of 5 per cent cyanide solution, with a charge of 6 tons of pebbles. About 3 tons of ore is thus treated at once. The remarkable feature of the process is that over 95 per cent of the silver in the ore is recovered by amalgamation in the tube mill. The remainder is largely recovered from the cyanide solution.

From a business viewpoint, the most important event of the year in the cyanide industry was the decision of the U. S. Court of Appeals sustaining the validity and fundamental nature of the Moore vacuum filter patents. Vacuum filtration transformed the cyanide process as applied to slime, and contributed largely to the increase in gold production by cyanidation. It was natural that so important a process should be modified by other inventors, and equally natural that the originator should consistently defend his invention. To the victor belong the spoils, but we are of the opinion that a policy of moderation will be more effective than one of strict demand for rights. Doubtless the end of the litigation is not yet in sight.

The steady advance of continuous decantation during the past year has been another feature of the cyanide process. Conceding the great benefits which resulted from vacuum fitration, it is nevertheless true that some other method of treating slime has been earnestly sought. If one such could be discovered which would eliminate the capital expenditure and cost of operation for filters, another great step in advance would be taken. Judging from the variety of conditions under which continuous decantation has been success-

fully applied, it would seem as though the desired process had been found. Sound in theory and comparatively simple in operation, it seems destined to grow in favor. Certainly the filter decision referred to above cannot militate against the spread of continuous decantation; rather will it tend to call attention to the merits of a non-filtering system which is already a proved success.

Regarding the agitation of slime pulps in cyanide solution, there has been a tendency to adopt a system of successive treatments with intermediate change of solutions, placing thickeners between the agitators. This practice has resulted in better extraction than could be obtained in one agitation for a long period of time. There are indications that mechanical agitation, or rather a combination of mechanical and air agitation, is growing in favor as against air agitation alone. The combination offers the opportunity to apply the two features to the work for which they are best adapted. Another reason for seeking some other method than air agitation is the objection to the Pachuca tank. Its height is objectionable in mill design where all appliances must be inclosed in the mill building, and the power consumption is quite an item.

Zinc dust precipitation has grown in favor for obvious reasons, and many installations of this system have been made during the past year, even in small mills of, say, 100 tons capacity. Experiments have been made in the manufacture of a zinc ribbon as a substitute for zinc shavings, but while the material itself has apparently given satisfaction, mechanical difficulties in its manufacture in large quantities have not been overcome. The method tried was to allow molten zinc to run in small streams over a rapidly revolving water-cooled cylinder.

The use of warm cyanide solutions has been adopted in some places, particularly in continuous decantation plants, where it is quite as easy to add hot water as cold in compensating the moisture loss in the discharged pulp. The general impression has prevailed that warm solutions are beneficial in cyanide extraction, but doubt has been raised in at least one instance, where a tabulation of recoveries from various departments of the mill system failed to show the expected improvement in recovery by cyanide.

Taken as a whole the progress in cyanidation has been very gratifying. No radical changes have been made in the chemistry of the process, and improvement has been along the line of better mechanical application. None of the proposed modifications of the standard process has met with success, although several of them reached, and even passed, the Patent-Office stage.

Improvements in the Metallurgy of Lead.

The use of accessory processes in preparing lead ore for smelting, and the recovery of by-products, were the two most important lines of development in lead metallurgy in 1912.

The increasing quantity of concentrates offered to reduction works, and the corresponding decrease in production of crude lump ore, have necessitated the adoption of some method of preparing the former for the blast furnace. Under former methods of roasting concentrates the product was too fine to form a large part of the furnace charge. The quantity of such material, however, was comparatively small, and by briquetting it with lime and flue dust it could be handled without undue loss; but with the great increase in quantity came an urgent necessity for preliminary roasting and agglomeration.

If we may judge from the wide adoption of the Dwight & Lloyd method of sinter roasting, this process is meeting the need fully. Not only has it proved beneficial in the smelting of concentrates, but it has demonstrated the value of "predigested food" for blast-furnace reduction. Furnace capacity is practically doubled when the charge is composed largely of sinter-roasted ore, and the smelting process runs more smoothly. Some Western plants are smelting in half the number of furnaces the same tonnage of ore formerly treated in all the stacks. This preliminary treatment has proved so satisfactory that one company has adopted the plan of crushing lump ore and sinter roasting it before smelting. At other plants where the Huntington-Heberlein process was adopted some years ago, the Dwight and Lloyd machines are being introduced. As to the relation of the Huntington-Heberlein process to the Dwight-Lloyd process some remarks by Dr. Heberlein in our columns devoted to Readers' Views and Comments in the present issue will be found of interest.

A commendable departure which was emphasized last year by the largest lead smelting company was the increased attention paid to the recovery of by-products, and the establishment of a technical research department. In the past, lead, copper, gold and silver have been the more tangible metals recovered, and these have received attention to the exclusion of others which have escaped unnoticed. Perhaps the centralizing of the industry, particularly the refining operation, has called attention to the minor quantities of other metals which gradually accumulate in flue dust, matte and bullion.

In any event, a number of metals are now being recovered as by-products from lead smelting and refining. Among these may be mentioned platinum, palladium, antimony, nickel, bismuth, tellurium, cadmium and arsenic. Some of these may not be of immediate commercial importance, and their cost may exceed their present value. On the whole, however, the indications are that the present policy of technical research will result in substantial economies in lead smelting, even if no radical changes in practice are evolved.

Developments in the Metallurgy of Copper.

Progress in the metallurgy of copper during the past year has been in the line of more careful dressing of ores, improvement in the basic-converting practice, and in the treatment of tailings.

In the dressing of ores much work has been done in the selection of the best type of machine for crushing jig middlings, the general practice being to reduce such material in either Huntington or Chilian mills. One company in Arizona, after a very extensive series of tests, has decided in favor of the use of Hardinge mills for this purpose.

Much work is being done in an effort to secure a suitable device for concentration of finely divided ore. The Wilfley

multiple-deck concentrating machine has been adopted in several plants. The Peck centrifugal slime concentrator has not made the success that was predicted for it, the difficulty being not in any defect in the principle of separation, but in the present inability to secure a machine that will "stand up" under the severe strain put upon it by the high velocity required for successful separation. A desliming device using the centrifugal principle, separating clayey material from finely divided silicious and sulphide material, makes a concentration of the sulphides practicable.

It is interesting to note in this connection the renewed use of the old round-table principle for the concentration of such fine material. The new tables are of a very modern type of construction, being made with frames of structural steel and in units of four decks.

Tailings from concentration of sulphide copper ores contain as a rule from one-half per cent to one per cent copper. Sooner or later efforts will be made for the recovery of the metal from this low-grade material. For many years, by leaching the old mine-dumps about Butte, many thousand pounds of copper have been recovered. This process, however, is very slow and requires for the best results a slightly acid water. The ferric sulphate usually present also is a valuable factor. Then, too, the mine-dump material is far more porous than concentrator tailings would be, the latter comprising material usually finer than one millimeter.

At one large plant a roasting-leaching method is being tried on a scale large enough to demonstrate its commercial value. The method consists in calcination in a McDougal furnace for the production of sulphate and oxide of copper, leaching this product with dilute sulphuric acid, and precipitating the copper by hydrogen sulphide formed by the action of sulphuric acid on low-grade matte.

The Hybinette process for leaching copper ores has been successfully applied in Norway. Ores which formerly were shipped to Sweden and to Germany are now treated locally. The ores are calcined with from 2 to 20 per cent sodium sulphate, the calcine is leached with dilute sulphuric acid and the copper electrolytically deposited from solution, insoluble anodes being used.

Wet methods have been in use many years, but without commercial success except in isolated cases. Progress such as that noted above give occasion for the hope that the many difficulties encountered by these processes may be overcome in the near future.

Only one or two plants in this country are now converting copper matte in acid-lined converters. Converting in basic-lined converters has proved far cheaper, and, because of the much longer campaign made possible by the long life of basic linings, the capacity of a converting department is very greatly increased.

Duties on a single basic lining, in a converter approximately eight feet in diameter and twelve feet long, have been recorded as high as 20,000 tons, with 40 per cent matte. When these same converters were used with acid linings the average duty per lining was only about fifty tons. Steps are now being taken for the use of much larger converters. A converter recently put into use is 20 feet in diameter and has a capacity of over three hundred tons of matte per day. What the duty per lining will be is hard to conjecture.

The thiogen process for neutralizing smelter gases, by reduction of the oxides of sulphur with petroleum, aims at the root of the smoke problem, that is, the elimination of not only sulphur trioxide, which is accomplished by the Sprague and Cottrell methods, but also of sulphur dioxide, which is probably the principal cause of injury to plant life, particularly to conifers. If Mr. Young, who devised this process, proves it to be commercially applicable, he will have solved a very troublesome problem. Extensive tests were made in California during the past summer, but the results have not been made public, and so far as can be gathered there is still work to be done before the process can be considered a commercial success.

The Metallurgy of Zinc in 1912.

The situation with regard to the production of spelter has not changed greatly in the past year In discussing processes for winning zinc from its ores, it must be kept always in mind that an ore-body of large size, such as the Butte and Superior, which is reported to contain 3,000,000 tons of 20 per cent zinc ore, can stand a great deal of costly experimenting, and a very expensive metallurgical plant, such as could not for a moment be considered for small mines.

It is safe to say that there is but one body of 15 per cent zinc ore in the United States with over a million tons actually in sight. There are not to exceed three with half a million tons each, and not to exceed eight with over one hundred thousand tons developed.

With large compact bodies of ore in this country more attention undoubtedly would be given to primary rather than secondary metallurgical processes, the aim being to produce spelter at the mine. There are so far but three primary methods to consider: retort-smelting, electric-smelting and electrolysis.

Practically all spelter now produced is made in retorts. That strong and well informed spelter manufacturers believe in the permanency of this condition is evidenced by their continued heavy investments in p rmanent smelting plants in the coal fields of Illinois. It is true that there have been two strong motives. First, the failure of the Kansas natural-gas supply, and, second, the possibility of marketing acid in the Central States; but permanent smelting and acid-making plants such as these are expensive affairs, and it may be taken for granted that the well-posted builders thereof have not made these investments without a most careful and thorough investigation of other possible methods. This is not the place to discuss the details of improvements in retort smelting. They are substantial but not radical.

Electric smelting of zinc ore is now being exploited on a commercial scale and at considerable cost in at least one plant. The information coming out from this side does not as yet offer much encouragement, although there is always hope for the electric furnace when its achievements in other lines are considered. Several of the best qualified experts in electric zinc smelting are continuing their development work quietly on an experimental yet gradually

increasing scale and many of the early serious technical difficulties have either been solved or brought near a solution. It is a slow, but apparently safe and sane development.

At least four serious attempts are being made by promoters of electrolytic processes to produce spelter commercially. In each case the electrolyte is a sulphate solution and insoluble anodes are used. With power at $25 per horse-power-year or less, and with cheap fuel available, these processes can make a very high-grade spelter at a direct operating cost which compares favorably with that of retort smelting. The spelter produced is 99.9 per cent pure, which is one of the points strongly urged, since such material commands a premium in the market; but with any considerable tonnage of such material offered regularly the premium would be quite certain to disappear. Cheap fuel for roasting and cheap power for electrolysis are essentials, and they are not often found together in the immediate neighborhood of Western zinc deposits. A rather more serious objection to the processes is the heavy cost of plant, which is from two to three times that of a retort smelter of equal capacity. This probably limits the use of electrolysis to large ore bodies or to large custom works centrally located, where the plant cost can be distributed over a tonnage large enough not to raise total costs unduly. Perhaps the most attractive feature of these processes is the fact that a very high recovery of the gold, silver, copper and lead is made in a concentrated by-product suitable for subsequent lead or copper smelting at small cost. On ores rich enough in these other metals this recovery seems sufficiently important to give electrolysis a strong advantage. The coming year should add greatly to our positive knowledge of this subject, since thorough trials under the best conditions are quite certain to be made.

Considerable of the work done by the secondary, preliminary or preparatory processes brings us to the conclusion that here the small mine owner has apparently a much better chance. He finds such methods wasteful, yet profitable. Wet concentration is, of course, the most common of them, and needs no description. The progress of the year seems to be toward improved tables, better classification and large slime plants. Like the improvements in smelting these are substantial rather than radical.

Flotation is without doubt as well adapted to many Western ores as it is to those of Butte or Broken Hill, and will come into wide use as results become better known. The method has the advantage that it can be applied by the owner of the smaller mines.

Dry concentration has had a quiet year, but at least two new attempts will be made in 1913 on zinc ores; one in Colorado, the other in Arizona. The Colorado attempt will use the McKesson screenless sizer in the effort to get proper table feed, followed by Sutton, Steele & Steele tables. The Arizona attempt is not yet very fully worked out in detail. Several promising dry concentrating machines are being developed, but the difficulties in the past have not been so much that the jigs or tables failed to make products as that the machinery and methods for the preparation of the dry ores and handling of dusut were not by any means satisfactory.

Magnetic and electrostatic separation continue to hold their own. Their field is comparatively narrow, being confined largely to the separation of certain sorts of mixed concentrates or middlings made by wet concentration methods, but this field they fill well. An interesting achievement is the success of the Huff electrostatic separator at Sunnyside mine, Eureka, Col., where 80 per cent of the material separated passes a 200-mesh screen, yet clean products are made at good capacity.

Leaching processes aiming to produce zinc oxide either for direct consumption as such, or for later conversion into spelter, are attractive on paper, but are no more successfulu metallurgically and financially than the hydrometallurgical processes for copper have been. If we had no other methods of winning zinc they could and would be used, but so far they have proved too expensive and troublesome.

At least two new proposals have been made during the year to extract the zinc as oxide from the slags of the American lead and copper furnaces. Results cannot be said to be satisfactory, but since such methods have been successful abroad it seems likely the troubles here are economic rather than metallurgical.

Preliminary fire concentration is being increasingly discussed and investigated in the West, particularly for the carbonate ores. There are places where fuel, labor and transportation conditions should apparently allow a low-grade zinc carbonate to be burned on grates to oxide, at a profit; such oxide to be shipped East for conversion into spelter. But here again the fact confronts the investor that such a plant could only succeed where backed by large and reasonably homogeneous ore bodies.

Just a Word to Promoters and Investors.

What Dr. J. E. Teeple says elsewhere in this issue on the necessity of early expert advice in the field of wood waste utilization, is true and timely and important far beyond the limits of that particular industry. It is a significant fact of the times that promoters and investors alike are beginning to think of chemical and metallurgical processes, besides mines, gas plants, electric lighting plants and trolley lines. It may have been simply a matter of taste which has invited this change of subjects or the public service corporations may have become troublesome. But whatever the reason, the fact is as stated.

This augurs well for the near future of chemical and metallurgical industries in this country. Both the honest promoter and intelligent investor are needed and needed badly. And the enthusiasm with which promoters and investors approach chemistry is delightful. But it is also dangerous. Too much is too often hoped for. As a single instance, plain miracles are sometimes expected by honest people from the electric furnace, like reduction without a reducing agent, etc.

A first advice to promoters and investors in their first venture in chemistry is, therefore, needed, and Dr. Teeple's article in this issue fills this want admirably. The quintessence of this first advice is that in order to promote a new chemical process to industrial life the first man to be seen is not a lawyer or a politician, but the very best technical expert who can be found.

Readers' Views and Comments

Sir Robert Hadfield on the Status of the Metallurgical Engineer.

To the Editor of Metallurgical and Chemical Engineering.

Sir:—With reference to the editorial in your November issue on "The Metallurgist in Steel," I very heartily agree with your conclusions, upon which may I be allowed to make a few remarks.

It has in the past been a puzzle to me to know why the "metallurgist" has not held a higher and better position in the scientific world than has apparently been the case. It has always been my object and aim to do my small share in raising his status. Is not the work done by the metallurgist even more valuable to the world than that done by any other profession from the point of view of adding to material comfort and convenience? Take away his work, and where, from the modern point of view, would those who live in the world be?

Startling as it may seem, the whole ground work of modern progress to-day turns upon the work done by the metallurgist. The mechanical and electrical engineer may design, but they one and all eventually have to come back to the men who produce material that is capable of meeting the required conditions of modern civilization.

In my presidential address to the Iron and Steel Institute I strongly emphasized this. In this connection I had some interesting correspondence with the able president of the American Institute of Electrical Engineers, Mr. Gano S. Dunn, who in his presidential address on the Relation of Electrical Engineering to Other Professions mentioned various classes of "human engineering," but omitted the metallurgical engineer. When I wrote him about this he answered that if he had had before him the facts mentioned in my presidential address, the metallurgist would have crowded out one of the other varieties of engineers. I take this as no little compliment, while at the same time being sorry for that class of engineer who was to be removed from his niche in fame. However, as his status is not mentioned there need be no broken hearts. We can each select the one who has least favor in our eyes. I suppose many of us would select the plumber.

Let me conclude by again saying how exceedingly valuable and just, so it seems to me, is your editorial on "The Metallurgist in Steel." It is most satisfactory to find your paper put forward such views on this subject.

London, England. R. A. Hadfield.

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The Electric Steel Furnace and the Use of Titanium in Foundry Practice.

To the Editor of Metallurgical and Chemical Engineering:

Sir:—I just have read the communication of Mr. Petinot in your November issue with reference to my article on "The Electric Steel Furnace in Foundry Practice." His main objection is due to a typographical error in the original article. Instead of "lost heats" one should read "lost heads," or better, "sink heads," that is to say, the part of the cast piece destined to prevent the formation of sinking holes by feeding the piece with steel still in liquid condition.

This answers Mr. Petinot's objections to the working conditions of electric steel furnaces, but his remarks suggest some more observations.

The electric steel furnace permits one to obtain perfectly deoxidized castings of higher quality than those made in ordinary open hearth or converter practice. This fact is at present agreed upon by all metallurgists and is proven by the continually increasing number of foundries adopting the electric steel furnace for the manufacture of high-grade steel castings.

Mr. Petinot concludes from his experiments with several hundreds of heats in an electric furnace that the deoxidation by calcium carbide in the slag is not always perfectly well obtained. I do not doubt his experience, but I beg to state that in the electro-metallurgical steel industry the earlier theories or views as to the exact action of the slag and the effects of calcium carbide in the slag are to-day already subject to criticism. Here I simply want to state that the operation of electric steel furnaces up to 12 tons capacity with many thousands of heats in foundry practice for production of steel castings of the highest quality as well as for all sorts of fine steels has proven that the electric furnace is exceedingly well suited for the turning out of first-class deoxidized material.

Mr. Petinot does not agree with me as to the usefulness of silicon-titanium alloy like that indicated by me. I am well aware of the fact that the great development of the use of titanium in steel practice is due to American metallurgy and I fully agree with Mr. Petinot that titanium has an excellent effect in cleaning the bath from impurities. But I cannot share his opinion regarding the addition of silicon-titanium compared to that of ferro-titanium and ferro-silicon, and without looking for a theoretical explanation, I beg to state that my works have decided to manufacture and to use the former complex alloy after a series of systematical experiments in foundry practice.

Silicon-titanium alloy is practically free from carbon and of sufficient density to be added in the electric furnace before the tapping and without remaining suspended in the slag. The silicon combined to the titanium in the form of the said alloy facilitates the formation, in the bath, of a slag of very fluid condition and separating easily.

In all our experiments with the electric steel furnace silicon has always been found to be very low, and with the exception of some qualities of special steels, it is always necessary to add silicon to the bath. It seems that actual electric steel furnace practice—as far as I know—is now sufficiently developed to do away with the fear of any influence of an acid furnace cover on the silicon contents of the bath.

Ugine, France. Paul Girod.

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The Huntington-Heberlein Process.

To the Editor of Metallurgical and Chemical Engineering:

Sir: Having come back from a three months' trip through the States and Mexico, I now have found time to read your extra edition reporting the proceedings of the Eighth International Congress of Applied Chemistry, in which you give an extract of the most important papers read and of the discussions which took place.

I find that the statement of certain facts regarding the so-called Huntington-Heberlein process may cause a wrong impression of the merits of this process as compared with the Dwight-Lloyd process (see page 596, Vol. X., No. 9 A.).

What I intended to state and did state after Mr. Dwight's very explicit speech on the progress of his process was that the Dwight-Lloyd machine giving a roasted product of a relatively thin stratum, say 4 to 5 in. thick, did not cause further cost of labor for breaking, and for this reason in connection with lead ores also offered an advantage from a sanitary point of view.

I mentioned that during the last years, of course, Mr. Huntington and myself had also further developed and improved the Huntington-Heberlein process so as to treat up to 40 and more tons of material in 24 hours in a single apparatus, and that by wetting the roasted product and letting it fall from a higher level the inconvenience of heavier expenses for breaking the cakes and of the development of obnoxious dust was greatly diminished.

Regarding the physical quality of the product I did not and cannot admit the superiority of the Dwight-Lloyd product over the Huntington-Heberlein roasted agglomerate.

Frankfurt a.-M., Germany. F. Heberlein.

The Rôle That Zinc Ferrites Play in Hydrometallurgy.

To the Editor of Metallurgical & Chemical Engineering:

SIR: At the present time there are many attempts being made to treat complex zinc sulfides by chemical leaching and subsequent precipitation. These attempts can be divided into two classes.

The first class used chlorine gas and makes a water soluble chloridized product. The second class avails itself of the familiar metallurgical roasting operation and then leaches with sulfuric acid or sulfurous or some caustic solution. Most of these proposals of either class use electrolytic decomposition of the solution for the preparation of the metal.

Whether or no the felicitous phrase "damn a wet process" and so consigning to the infernal abysses these numerous sincere and industrious strivings to increase our natural mineral wealth by applying the methods of the chemical laboratory to the works can be legitimately applied to the hydrometallurgical trials is, of course, a question to which the future alone can give a pragmatic answer. Possibly time will prove the contention of the advocates of the electric zinc furnace that it has certain innate metallurgical points of superiority over leaching apparatus. But, be that as it may, the great activity of experimenters in this country, Canada and England demand respect from all metallurgical engineers.

The question of roasting of complex zinc sulfides has a most direct and practical bearing on the hydrometallurgy of any wet process. The "old chloridizing" or sulfating roast with or without mixtures of salt or crude acid sodium sulfate has been known in the old Henderson process, in the Ziervogel process, and in the hyposulfite leaching of chloridized silver ores. In any process that depends on desulfurizing partially or completely with the idea of making a product soluble in any reagent, the physics of the process and the changes in the physical microstructure vitally affect the ease of solubility of the product. Indeed we are here in the borderland of physics and chemistry and the problem can be stated truly to be one of physical chemistry or of "physical metallurgy."

In heating up any stable substance such as fireclay, it assumes, according to temperature and time, a denser and harder structure or in short the play of atomic and molecular forces results in a configuration of braced and interlocked dynamism. This can be true either of the intra-molecular stresses or of the extra-molecular stresses. At any rate as a matter of practical fact the soluble quality of the roasted product will vary greatly and on holding a uniform quality it will be found that the whole question of practical success of the process will hang.

One of the chief of these chemical compounds that can be definitely isolated is zinc ferrite, $ZnO\,Fe_2O_3$ or $Zn\,Fe_2O_4$. This may be formed in the wet way or it can be formed in the dry way. In the wet way it is probably formed by the double precipitation of the oxides of iron and zinc out of a strongly ammonium chloride solution and drying in vacuo. Franklinite, a well-known ore of zinc is a zinc ferrite with part of the iron and zinc replaced by manganese. In the dry way it is simply made by heating an intimate mixture of zinc oxide and iron oxide together.

The writer found in 1903 that the solubility of this product in such reagents as ammonium chloride, ammonia, sulfuric acid, diminished greatly as the time and temperature of heating and the rate of cooling varied. Indeed by heating at about 1300 deg. C. for 12 hours I made a hard dense zinc ferrite that was practically inert chemically. I lay stress on the factor of time as affecting the solubility.

Now zinc blende which is the raw material which all of these processes use is always associated with some mineral form of iron sulfide. In the roasting of such ores preparatory to leaching the tendency is to make zinc ferrite and the more this tendency is allowed to exert itself the greater will be the difficulty of solution.

In a recent meeting of the Faraday Society there was a symposium on various phases of magnetism. In one of the papers the author, Prof. E. Wedekind, pointed out how different salts where ferric oxide played the role of an acid, such as zinc ferrite and of the type $M_2Fe_2O_4$ like magnetic iron oxide or iron ferrite (Fe_3O_4 or ferrousferric oxide) had certain marked ferro-magnetic properties. A long series of such salts as cobalt ferrite, calcium ferrite were given.

It is a long way from Broadway to the copper river district of Alaska, but modern commerce is so related. It seems a long way in the physical chemical world between the magnetic qualities of iron compounds to the hydrometallurgy of zinc. But the case of zinc ferrite suggests the possibility that calcium ferrite and numerous other ferrites are formed in roasting.

It seems a positive dictate of both experimental and theoretical chemistry that successful leaching of zinc ores can only be obtained by a careful investigation of this rather new field of physical chemistry—the formation of new insoluble compounds in the dry way. What little is known about it almost haunts one with the idea of what might be known of the subject—of the move of heaven and hell—than is dreamt of in our philosophy.

Hartford, Conn. WOOLSEY MCA. JOHNSON.

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Code of Ethics of American Institute of Chemical Engineers.

To the Editor of Metallurgical & Chemical Engineering.

Sir:—In your December issue you published a letter from Dr. Joseph W. Richards regarding the Code of Ethics which was then before the American Institute of Chemical Engineers, and which since then has been adopted by the Institute. I was chairman of the committee that drew up the Code of Ethics, and Dr. Richards attended one of the meetings. At that meeting we tried to meet most of the objections which Professor Richards raised. The code having been adopted, it is perfectly proper for Professor Richards to advocate in a proper manner and place a reconsideration of the action by the Institute or to amend the code in such a way as seems desirable. I would like, however, to call attention to the following points:

It is a great pleasure for the members of the Institute to realize that Professor Richards does not require a Code of Ethics. It is to be hoped that no member of the Institute requires a code, but that is not the important question.

The important question is: Will a Code of Ethics be of assistance to the members of the Institute? Will it help to build up a higher ethical standard among them, and will it help to build up in the mind of the public a better appreciation of the moral excellence of the members of the Institute and the profession generally?

Some of the features of the code are undoubtedly unnecessary except as being a part of the logical presentation and development of the code. In such a presentation we naturally start with axioms which might appear gratuitous. As we read over the features of the code, it seems that the code offers valuable suggestions of methods of building up the profession. It urges mutual helpfulness and a general attitude of defense of chemists. It declares against sensationalism in advertising and against unreasonably low charges for professional work. It emphasizes the desirability of chemists giving credit to others wherever such credit is due. These and many other points are positive in their suggestiveness. Is any of us so good that he can overlook or ignore these positive suggestions? Are we all of us so helpful to our fellow chemists; do we always so avoid sensationalism; do we always so give credit to others for professional work, that it is unnecessary to be reminded on these points?

The Code of Ethics of the American Institute of Chemical Engineers gives backbone to our moral purpose. We can hardly conceive of it as limitating anyone's proper freedom of action. The most pronounced individualist will be as free under the code as he would be without it; but it adds to

such freedom a recognition of the profession as something of an entity—something that we should try to improve and exalt. I am confident that many members of the Institute joined it because they believed that it would raise, both ethically and intellectually, the standards of the chemical profession and believed that the indirect benefits derived from the Institute would be of infinite value.

The adoption of the Code of Ethics puts an emphasis on the ethical phase just as its educational requirements put an emphasis on the intellectual phase. Both are important parts of its reason for existence—neither should be ignored.

Brooklyn, N. Y. G. W. Thompson.

Perkin Medal Awarded to James Gayley.

At the regular annual meeting of the Perkin Medal Committee the medal was awarded for 1913 by a unanimous vote to Mr. James Gayley for his dry-blast process in pig iron manufacture.

The Perkin Medal Committee consists of delegates of the Society of Chemical Industry, the American Chemical Society, the American Electrochemical Society, and of their New York Sections, and recommendations are made by the various national chemical societies of this country. The presentation of the Perkin Medal to Mr. Gayley will be made at the regular January meeting of the New York Section of the Society of Chemical Industry.

Electric Steel Furnaces.

As an indication of the present status of the electric furnace in the steel industry the following list of licenses of the Girod furnace will be found interesting:

Rubery Owen & Company, Darlaston, England; Gib. Ansaldo & Company, Genoa, Italy; Putiloff Works, St. Petersburg, Russia; Bethlehem Steel Company, South Bethlehem, Pa.; Krupp & Company, Essen, Germany; Oehler & Company, Aarau, Switzerland; Société John Cockerill, Seraing, Belgium; Stotz & Company, Kornwestheim, near Stuttgart, Germany; Stahlwerk Becker, Krefeld, Germany; Gutehoffnungshütte, Oberhausen, Germany; Ternitzer Stahlwerk, Scoheller, Ternitz, Austria; Danner & Company, Judenburg, Austria; Ungarisches Staats-Stahlwerk, Diosgyor, Hungary; Simonds Manufacturing Company, Lockport, N. Y., and two other American works whose name is not divulged at this time. One of these American works will install a 3-ton Girod furnace to be used exclusively in the manufacture of steel castings.

Thirty-Third Annual Report of the Director of the United States Geological Survey.

In the advance sheets of the director's report for 1912, Mr. George Otis Smith calls special attention to the need of a new building for the Survey. In considering the general unfitness of the buildings now occupied by the Survey, the director finds that they are inadequate from the point of view of the health and efficiency of the employees, as well as offering great risk from fire. The offices are crowded, and in the summer season some of them are too hot for occupancy. There is lack of fresh air and light, and too much noise and dirt from without; and the prospect of increasing the efficiency of the Survey under present conditions is remote.

The risk from fire is a menace second only to the existing danger to the health of the employees. The Survey's papers, records, maps, reports, etc., have an inventory value of $4,840,000. If these were lost, it would be impossible to replace them without incurring an expense equal to their present value, and even then it would require observations extending over long periods of time to replace some of them. The director urges the need of adequate quarters, and states that plans for a building have been drawn and referred to the House committee on public buildings and grounds, of the Sixty-second Congress.

Oxygen from Liquid Air.

The **Linde Air Products Company** of Ohio has commenced the installation of Plant 5 in Detroit.

Preliminary work is now complete for the establishment of Plant 6 which will go forward at once in Boston. The new Boston plant will have a capacity of 15,000,000 cu. ft. of oxygen per annum and will involve an investment of approximately $500,000.

The Linde Company is expanding its capacity in advance of requirements with a view to supplying local needs as rapidly as they develop at so low a price that the largest possible industrial use of oxygen will be made probable.

The use of commercial oxygen is strictly limited by small differences in selling price and the business must necessarily depend upon a very large output with a rather small margin of profit.

This calls for large investments and the Linde Company has the courage of its convictions.

Transactions of Eighth International Congress of Applied Chemistry.

There seems to be some misunderstanding among members of the Eighth International Congress of Applied Chemistry as to its printed report. This report will consist of 26 volumes of original communications, one volume of discussions, one volume on the Congress meeting itself and an index, or a total of 29 volumes or about 6500 pages. Prior to the Congress 24 of the 26 volumes of Original Communications had been printed; the two additional volumes of Original Communications have since been set up in type and the manuscript for the discussions and for the volume on the Congress itself has been practically completed since November 4, 1912, but is still awaiting manuscript from a few belated but important contributors, both here and abroad; the index cannot be prepared until all matter is in type and ready for printing, but the most of the work for that is finished for the first 26 volumes.

The date originally set for delivery of the entire Report was December 31, 1912. In view of the delay above described delivery to transportation companies cannot begin until toward the end of February, 1913; this will be automatic and will not be hastened by special inquiry; it is therefore requested that such inquiries be not made.

Bound volumes will not be delivered until the end of May, 1913; orders for bound volumes will not now be accepted. Members will be advised by letter at their last known address of the time their volumes left the Rumford Press at Concord, N. H., and by what transportation line. All inquiries as to reprints, corrections in papers appearing in volumes 1-24, imperfect volumes or sets and lost shipments, as well as all statements of change of address should be addressed to the Rumford Press, Concord, N. H.

The office of the Secretary of the Congress has been removed to 90 William Street, New York City, and all other communications should be so addressed.

Patent Reform.

Resolutions of American Institute of Electrical Engineers.

The Board of Directors of the American Institute of Electrical Engineers has adopted the following resolutions:

"Whereas, there are pending before the Congress numerous bills affecting and greatly modifying the Patent System in the United States, and

"Whereas, the Patent System has been, and is, a tremendous factor in building up the present industrial prosperity of this country, thereby greatly contributing to the prosperity of the country as a whole, and

"Whereas, any untoward change in the patent situation might disastrously affect this condition of industrial and general prosperity, and the conditions contributing to their continual augmentation, and

"Whereas, in view of the intimate relation of the Patent System to the general welfare, no action looking toward any radical change in the Patent System should be taken without most careful consideration, and

"Whereas, in our opinion, proper consideration of such important changes as are proposed can be had only by an unbiased, non-partisan commission, made up of men from various walks of life and not from any one vocation, or interest,

"Be It Resolved, that the American Institute of Electrical Engineers, acting through its officers and board of directors, respectfully urge the Congress of the United States that they provide for a Commission, made up of unbiased, independent, non-partisan men of such national standing as will command the respect of the whole country; and chosen from different walks of life; and not more than one from any one calling or interest; and serving without pay. Such Commission to hold public hearings, and otherwise, as may appear to them best, to make a thorough and careful study of the American Patent situation, and to prepare and submit a comprehensive report and recommendations to Congress for such changes, if any, as may, as the result of their study, appear to them expedient, whether in the Patent Office, in the method of court procedure, or in the organic Patent Law, and recommendations as to the Legislation they would propose for effecting said changes. And that we further respectfully urge that the Congress make ample provision for the expenses of said Commission, and

"Be It Resolved, that we respectfully urge the Congress of the United States to hold in abeyance all proposed Legislation affecting the Patent System in whatsoever way until such time as the said Commission shall have had ample opportunity to hold the said hearings, and make the said study and report, and

"Be It Further Resolved, that these resolutions be printed and a copy be sent to each Senator and Representative of the United States who is a member of the Senate or House Committee on Patents."

Mr. Ralph D. Mershon is the president and Mr. F. L. Hutchinson is the secretary of the American Institute of Electrical Engineers.

The Iron and Steel Market.

The slowing down which usually occurs in the iron and steel market at the close of the year was observed in December, but was less marked than usual in that the pressure for deliveries continued heavy. Buyers were as insistent as ever in urging the mills to better deliveries. In forward buying there was a notable decrease, except as to railroad buying, which continued heavy. In specifications against contracts already placed the month made a good showing, though the total tonnage specified was not as great as that of November, the decrease being probably due to the fact that some contracts, nominally written to last to December 31, had already been worked out.

There were no important price changes during the month. Effective December 16 the American Steel & Wire Company advanced its prices on wire products $1 per ton, putting nails on the basis of $1.75 per keg. Such an advance had been made by two or three independents about the middle of October, in the expectation that a general advance would thus be precipitated.

The scarcity of crude steel became still more acute in December, a point being reached at which there was practically no quotable market. The regular large producers had long been out of the market, and only occasional lots could be picked up from brokers or from outlying mills. An Alabama interest, for instance, offered a moderate tonnage in the North for next year's delivery, and succeeded very quickly in selling on the basis of about $29, Pittsburgh.

The famine in unfinished steel has greatly disturbed many of the independent finishing mills, particularly sheet and tin mills, which must depend upon purchased steel for their operation. The prospect is that some of them will lose time in the first quarter of the new year from not having steel. The scarcity of unfinished steel, however, is a natural outcome of conditions. In the first place, the normal alignment of the steel industry, the alignment that has prevailed ever since the steel industry reached important proportions is that of their being an excess of finishing capacity over steel-making capacity. In the laying out of an individual plant, with diversified product, it is always regarded as desirable to have an excess of finishing capacity, for if perfect balance could be secured in mechanical operation, such balance would be impossible in the market. A mill cannot be certain of selling its output in precisely the proportions the different finishing mills would make, if operated full. It is easy to slow down or to close a given finishing mill, whereas to slow down the steel-making unit is expensive, there being little reduction in overhead. When the individual plant is naturally planned for more steel finishing than steel-making capacity, so much more is the alignment in that direction when the steel-making unit is under one ownership and the steel finishing unit is under another. When, therefore, there is a market which would involve the operation of all the finishing capacity, there is not enough steel to supply it.

Another cause of the famine in steel is the continued sharp trend in demand toward open-hearth steel. The greater portion of the finishing capacity of the country chances to be so arranged that it can roll either Bessemer or open-hearth steel, whereas there is practically no flexibility in the steel-making units. The Bessemer plants can make only Bessemer steel and the open-hearth plants only open-hearth. For the idle Bessemer plants to relieve the scarcity involves their making billets or sheet bars for the market, and this they are not all equipped to do. We said there is "practically no flexibility" in the steel-making units. There is none at the moment, but there is some by rearrangement, whereby Bessemer vessels may sometimes be made to form the first link in the practice of the duplex process, either by using open-hearth furnaces already built, or by building them. A recent instance of the latter is the erection in the past year of two 250-ton tilting furnaces by the Lackawanna Steel Company, to practice the duplex process with existing converters.

Finally, billets and sheet bars have been made scarce by the heavy demand for rails, since many of the mills are interchangeable as to billets or rails, sheet bars or rails, or the whole three products. Rails are a finished product, sold to consumers, and a producer having the choice of selling rails or sheet bars, or rails or billets, chooses the rails apart from considerations of price and cost of manufacture, regarding rather the general principle that the actual consumer, rather than a detached finishing mill, presents the trade which in the long run it proves best to serve.

Pig Iron.

The pig-iron market was practically stationary as to prices during December, and was rather slow as to transactions. There was a strong undertone to the market, which did not depend upon current demand, but rather upon the facts that the operating furnaces were already well sold up, and that on account of the very high prices ruling for coke it was difficult to start any of the idle furnaces. The only advances over quotations in last report are of 25 cents in foundry iron in the valleys and in eastern Pennsylvania. We quote: Bessemer, $17.25; basic, $16.50; No. 2 foundry, $17.50 to $18; forge, $17 to $17.50; malleable, $17 to $17.50, f.o.b. valley furnaces, 90 cents higher, delivered Pittsburgh; No. 2X foundry, delivered Philadelphia, $18.50 to $18.75; No. 2 foundry, f.o.b. Chicago furnaces, $18; No. 2 foundry, Birmingham, $14 to $14.50.

Steel.

The market has become purely nominal, as already noted. Prices last quoted, which were based upon actual transactions, and which would probably prevail had the large mills any tonnage to dispose of, are as follows: Bessemer billets, $27; sheet bars, $27.50; open-hearth billets, $28; sheet bars, $28.50, f.o.b. maker's mill, Pittsburgh or Youngstown. Under special cir-

cumstances, sales of open-hearth billets have been made at $29, Pittsburgh. Rods are $30, Pittsburgh, with sales at that figure.

Finished Steel.

Regular steel prices showed no important change in December, there being simply an advance of $1 a ton in wire products. On the majority of products premiums ruled for early deliveries, but such prices cannot be quoted, as the premiums increase the smaller the order, with no definite limit, and also increase with the nearness of delivery. In general there are many products which have commanded premiums of $2 to $4 a ton in carload lots for delivery within one to three weeks.

Regular prices for forward delivery are given below, prices being f.o.b. Pittsburgh unless otherwise stated:

Rails, standard sections, 1.25 cents for Bessemer, 1.34 cents for open-hearth, f.o.b. mill, except Colorado.

Plates, tank quality, 1.50 cents.

Shapes, 1.50 cents.

Steel bars, 1.40 cents.

Common iron bars, 1.65 to 1.75 cents, Pittsburgh; delivered Philadelphia, 1.67½ to 1.75 cents; f.o.b. Chicago, 1.60 to 1.65 cents.

Steel hoops, 1.50 cents.

Sheets, blue annealed, 10-gage, 1.65 to 1.75 cents; black, 28-gage, 2.25 to 2.35 cents; galvanized, 28-gage, 3.40 to 3.50 cents; painted corrugated, 28-gage, 2.45 to 2.50 cents; galvanized, 3.45 to 3.50 cents.

Tin plates, $3.60 for 100-lb. cokes.

Merchant steel pipe, ¾ to 3-in., jobbers' carloads, 80 per cent. off list.

Steel boiler tubes, 3½ to 4½-in., 71 per cent. off list.

Standard railroad spikes, 1.85 to 1.90 cents.

Button head structural rivets, 2.20 cents; cone-head boiler rivets, 2.30 cents.

Tubular Goods Revision.

Under the lead of the National Tube Company, which on November 27 announced to its customers and competitors the revised lists it would work under beginning January 1, 1913, a general change has been made in merchant pipe and boiler tubes.

The old merchant pipe list carried the weights per foot and thicknesses of wall based upon wrought iron, and when steel was adopted, with about 2 per cent greater specific gravity, the mills departed from the standard thicknesses and adhered to the standard weights per foot. The present revision restores the old thicknesses, thus increasing the weights about 2 per cent, but the computations are more exact than formerly. Next, the list prices per foot are revised so that they conform more closely to the principle of making the list price produce a price of 10 cents per pound. Until now there have been made two weights in merchant pipe, 6-in. and under, the "card weight" conforming to the card, and "merchant weight," a weight indefinitely lighter, and sold in the market at one point discount (about $2 per net ton) less than the price of the card weight.

The revision of weights and list prices made on the whole a slight advance in prices per foot, though a slightly greater reduction in prices per pound, and at unchanged discounts the net prices per foot would be slightly advanced. To avoid the appearance of making any profit out of the rearrangement, when it is made solely in the interest of improving the quality, the manufacturers have made the old discount on merchant weight apply to the new full weight pipe. Thus the price per foot of card weight is slightly reduced, and a buyer formerly taking merchant weight secures full weight at a very slight advance compared with the much greater weight furnished.

The boiler tube list was somewhat similarly revised, but as list prices were somewhat reduced and as contracts were on books extending well into the new year, the discounts were reduced about one point, thus effecting a slight advance.

The Non-Ferrous Metal Market.

General dullness has characterized the non-ferrous metal market for December. Copper has been stagnant, lead has been greatly reduced in price, tin is offered freely without premium for immediate delivery, and spelter has been offered liberally at low prices without finding buyers.

Copper.—Since our last report Lake copper has had only a nominal price, and little business has been transacted. The principal sellers have maintained the price, and outsiders have sold the metal at concessions. Moderate sales have been made in electrolytic. The impression prevails that consumers cannot much longer stay out of the market. The latest quotations are: Lake, 17½@17⅝ cents; electrolytic, 17.35@17.40 cents.

Lead.—Twice since our last report the principal producer cut the price, first to 4.50 and later to 4.35 cents. In each case the cut was met by other sellers, who reduced their prices correspondingly. In spite of the low prices prevailing, little business has been transacted. The metal is quoted at 4.15@4.17½ cents, St. Louis, and 4.30@4.35 cents New York.

Tin.—Lower prices prevailed in the London market, and this developed a fair business with American consumers. The premium on spot tin has disappeared, and December tin was quoted at 49¼ cents.

Spelter.—Prices have continued to decline, and some business has been effected at 7.10 cents. The prospect of importations of foreign spelter has affected the domestic market, and removed the customary differential between New York and St. Louis markets. The latest quotations are 7.05@7.10 cents, St. Louis, and 7.10@7.20 cents New York.

Notes.

Metal shipments from Nome, Alaska, for the navigation season of 1912 have been made public by R. W. J. Reed, deputy collector of customs. Placer tin mined in the vicinity of Nome, 173 tons; placer tin shipped, 129 tons; gold dust and bullion shipped, 160,079.69 oz. valued at $2,931,478.26. The gold output for the season probably will be increased by about $100,000 by dredges operating during November.

Pebbles for the Hardinge regrinding mills at the Tomboy mill, Telluride, Colo., are prepared at the mill from selected pieces of mine rock composed of rhodonite and quartz. The rock is broken into rough spherical shapes and charged into the mills at the rate of about 170 lb. per day. Some of the worn pebbles show ridges of the hard quartz above the general surface of the rhodonite. The pebbles give satisfaction, and are used in preference to imported pebbles which would cost about $28 per ton delivered at the mill.

The Bureau of Mines has recently issued the following publications of interest to mining and metallurgical engineers: *Technical Papers,* No. 22, Electrical Symbols for Mine Maps; No. 24, Mine Fires; No. 25, Determination of Water in Petroleum and its Products; No. 26, Determination of the Sulphur Content of Fuels, Especially Petroleum Products; No. 28, Ignition of Gas by Standard Incandescent Lamps; *Bulletins,* No. 43, Fuel Values of Gasoline and Denatured Alcohol for Internal Combustion Engines; No. 44, First Mine-Safety Demonstration; No. 45, Investigation of Explosion-Proof Motors; No. 47, Notes on Mineral Wastes. These publications can be had on application to the Director, Washington, D. C.

Timber Preservation at the Homestake.—The cats and tanks at the Homestake mill, South Dakota, are of California redwood, with the exception of a few thickening tanks which are of cypress. They are painted on the inside with P. & B. paint, and on the outside with a mineral paint containing more or less red oxide of iron. A timber-treating plant is installed for impregnating wood with creosote or dead oil of coal tar. The usual treatment is a hot bath of two hours' duration at a temperature averaging 216 deg. Fahr., followed by a half-hour contact at 180 deg. Fahr. or 190 deg. Fahr. The cost is about ten cents per cubic foot. Railroad ties and 2-in. plank for mortar blocks are thus treated.

Notes on Chemistry and Metallurgy in Great Britain.

(By Our Special Correspondent)

The Iron Market.

The effect of the steadily increasing demand for iron, both at home and abroad, which set in before the middle of this year, has been to send up prices to figures which have not been reached since 1900; and there is every probability that the rise will continue, because the demand seems likely to become still greater. Many manufacturers are showing disinclination to make further purchases of pig-iron at the present high rates, whilst the pig-iron makers assert that the price of manufactured articles has risen proportionately higher than that of the raw material—a contention which certainly appears to be supported by a study of the quotations during the last few months; and, in any case, the advance unquestionably began with manufactured products before the price of pig-iron increased.

At the close of 1911 Cleveland warrants stood at 50s. 10d., and the stock at Middlesborough amounted to rather more than half a million tons, whereas at the end of last October it was only slightly over a quarter of a million tons, and the quotations touched 67s. Since the coal strike both coal and ore have increased in cost, and the replenishment of the stock depleted as a consequence of the strike could only be possible at greater cost; but had there not been any coal strike the increased activity in the iron trade would have been felt only a little earlier, and an uninterrupted production of pig-iron would not have materially affected the advance in price during the last three months or even sooner.

There are now very few idle furnaces in England or Scotland—although the total number now in blast is only some six more than at the end of last year—but their output is inadequate to meet the requirements of the iron and steel works, which are in turn unable to keep pace with the demands of the consumers. It is not magnifying the truth to say that every iron and steel works is being run at the fullest capacity; many works are being extended to cope with the increasing influx of orders; and it is anticipated that unless the supply of raw iron can be considerably augmented the inquiry for the home market will, at no very distant date, be such that it will absorb almost the whole of our production and very largely reduce the amount available for export when still heavier shipments than are being made now will in all likelihood be called for.

The question is how the increased consumption of pig-iron is to be met soon enough. The output from the furnaces now in operation cannot be enlarged to any great extent, and the provision of new ones in sufficient numbers is not practicable in a few weeks, while the localities in which electric smelting could be quickly put into practice are very few and even in these the working costs would be prohibitive for iron ore reduction in England. The old proverb, "No pleasure without pain," is emplified by the embarrassing situation resulting from a most gratifying revival of the iron trade.

Poisonous Gases from Oilfields.

A paper on this subject was read by Mr. H. S. Shrewsbury before the Society of Public Analysts at the meeting on Nov. 6. Recently a negro was killed by breathing the gas at the bottom of a pit under an oil derrick close to the Pitch Lake at La Brea, Trinidad. The pit was some 10 ft. deep and surrounded the casing of the tubular oil well, from which the gas most probably overflowed into the pit. While working in the pit the man became giddy and had to be helped out. Twelve hours later he was dead.

A sample of gas taken from the top of the oil tube was analyzed by the author, who found that its composition was: sulphuretted hydrogen, 0.1 per cent; carbon monoxide, 1.1; saturated hydrocarbons, 4.4; unsaturated hydrocarbons, 2.5; oxygen, 8.7; carbon dioxide, 11.9; hydrogen, 18.8; and nitrogen, 52.5 per cent. Assuming all the oxygen and some of the nitrogen to be derived from the air, the amount of air present was 43.4 per cent, and the composition of the gas as it issued from the ground was: sulphuretted hydrogen, 0.2 per cent; carbon monoxide, 1.9; unsaturated hydrocarbons, 4.4; saturated hydrocarbons, 7.8; carbon-dioxide, 20.9; hydrogen, 31.4, and nitrogen, 33.4 per cent.

A Wynter Blythe states that 0.05 per cent of sulphuretted hydrogen in air is the maximum that can be breathed with safety; that 0.08 is dangerous, and 0.1 to 0.15 fatal to human life. According to Haldane, more than 0.15 per cent of carbon monoxide is dangerous, and 0.4 per cent would kill in a moderately short time. The gas as it issues from the ground is extremely poisonous; and when diluted with 43 per cent of air would kill in a short time—as indeed it did.

The author visited the Pitch Lake and observed that the surface is covered with little pools and channels of water through which gas is constantly bubbling, and gas also issues from the pitch itself. This gas has exactly the same odor as the sample described—the small percentage of sulphuretted hydrogen mixed with the hydrocarbons producing a sweet and tar-like smell. The author also witnessed the interesting fact that small fishes live in the pools through which the gas bubbles, notwithstanding its poisonous character. It appears to your correspondent that air containing 11.9 per cent of carbon dioxide is sufficiently poisonous without the CO and H_2S.

The Granular Structure in Metals.

It is a matter of common knowledge that reheating steel at temperatures below 900° C. renders the structure of the metal granular and induces brittleness. F. Robin (Comptes. Rend., 1912, 155; 716-719) states that he has found that other metals are similarly affected, and that hammering, deformation and compression likewise tend to develop a coarse, granular structure. In the case of local deformations, such as bends, the granules formed in the deformed area appear to mutually limit their development; while just outside this area their development is greater and extends gradually into the unaltered portions. When an annealed metal is locally hardened by forcible deformation, such as shearing, punching, or bending, and is re-annealed at various temperatures (presumably below the change point) for about half an hour, the invasion of the unchanged area by large granules is distinctly noticeable after five minutes. Such granules appear to be subject to much the same conditions as those produced by annealing, and they extend as far as 7 to 12 mm. into the unaltered region.

The extensive manufacture of articles from stamped, bent and perforated sheet metal invests this subject with a considerable degree of industrial importance. The remedial measures suggested by the author are, for iron, heating to above 900° C., and for non-ferrous metal, the addition of other metals.

Electrolytic Tanning.

A process of tanning by electrolysis has been devised by Dr. L. A. Groth, and a small plant for demonstration purposes on a commercial basis is being put down at Mr. C. Smith's tanyard, Kidderminster, by the Local Electric Lighting and Traction Co., under the direction of the inventor.

The time required for tanning heavy hides by the ordinary processes extends to several months; and Dr. Groth claims that by his method they can be purely and effectively tanned in six weeks, yielding a leather of very high quality.

The operation of the plant is practically automatic, and the necessary attendance throughout is furnished by two lads; whilst the cost of production is said to show a very considerable saving as compared with that of tanning by the usual processes. An ingenious system of automatic control is designed to prevent injury to the skins or the tan-liquor, and any departure from normal conditions is at once signalled to the attendant by bell and the lighting of a lamp at the spot requiring attention.

A Reinforced Concrete Water Main.

At Luton, Beds., a ferro-concrete rising main about a mile long and having an interior diameter of 27 in. has been constructed by a London firm. The steel reinforcement measures

2½ per cent of the volume of the concrete, which has a thickness of 3 in. and is without lining of any description. The main stood a continuous test at a pressure of 60 lb. per sq. in., and when completely filled the loss after standing twelve hours was only four gallons. As the valve at the lower end was not readily accessible and might possibly not have been quite tight, the main was reported as thoroughly water-tight. The lowest tender for cast-iron pipes of the same capacity was £2-2-7 per yard, and the cost of the concrete main, delivered at Luton, was £1-7-7 per yard.

Castner-Kellner Alkali Co.

The annual meeting of this company was held late in November in London. The chairman, Mr. G. W. Balfour, announced that the net profit on the year's working was £172,062, against £178,853 for the previous year; but the reduction was due to special circumstances. The depreciation reserve against patents, land, buildings, etc., valued at £737,000, now amounted to £322,500, out of which sum £60,000 had been invested by reducing their debentures.

The general reserve of £177,500 was invested in readily realizable securities, and could be employed in any way the directors chose. Given continued prosperity, the directors might consider the advisability of reducing the sum carried to general reserve in future and increasing the dividends. A final dividend of 12½ per cent was agreed to, making 20 per cent for the year.

Alby Carbide.

The sixth annual general meeting of the Alby United Carbide Factories, Ltd., was held on Nov. 28 in London, under the presidency of Mr. A. E. Barton, chairman of the company, who said that the profits for the year ended June 30 showed an increase of practically 100 per cent on those for the previous year, which in turn were 58 per cent greater than in 1909-10. The balance sheet shows that the net income for the 12 months June 30, 1911-1912 was £72,792, and this sum, with £493 brought over, suffices to write off £6,514 for depreciation; £2,000, the balance of the Atkins Acetylene Dry Generating; £37,012, the entire amount of preliminary expenses, and to provide a final dividend of 3 per cent on the ordinary shares, making 6 per cent for the year, leaving £4,097 to be carried over. The dividend for the last financial year on the shares held by the company in the Meraker Company amounted to nearly twice the investment.

The present output of the Odda factory is 32,000 tons of carbide per annum, and in order to enlarge the works for turning out 80,000 tons per annum, the capital has been increased during the past year to £550,000 by issue of 150,000 5½ per cent accumulative convertible preference shares. The company's interest in Alby Carbide Works (Sweden) has been acquired by Nitrogen Fertilizers, Ltd., for 142,380 £1 shares in that undertaking, and by the purchase of 50,000 additional shares the company now holds 192,380 shares out of a total of 220,000 in Nitrogen Fertilizers, Ltd.

Engineering Imports and Exports.

The returns issued by the Board of Trade again show substantial advances in the value of both imports and exports in the ten months ended on October 31 as compared with the same period of last year. Imports of iron and steel, including manufactures, totalled £10,489,972, an increase of £1,380,752; and exports amounted to £39,523,957, an increase of £3,719,742. Imports of other metals, including manufactures, are valued at £25,558,983, an increase of £2,582,495; whilst exports reached £10,014,596, an increase of £944,294. In electrical goods the imports are put at £1,176,199, a rise of £32,307; and exports went up to £3,745,349, an improvement of £1,458,481. Machinery was imported to the value of £5,645,823, an increase of £803,294, and was exported to the amount of £27,502,255, an increase of £2,057,878. Imports of new ships were £26,652, a fall of £34,341; but exports were £5,673,942, a rise of £1,260,870. The figures for October solely show increases all round. Imports of iron and steel were £349,706 higher and exports were £1,022,072 better than last year; imports of other metals rose £1,082,431, and exports improved by £284,910; imports and exports of electrical goods went up £8,754 and £250,563 respectively; machinery shows increases of £219,113 in imports and £537,435 in exports; and imports of new ships rose £1,267, whilst exports were £867,310 better.

The aggregate increase in the value of the imports for the ten months is £4,798,848, and that of the exports is £9,441,265. Taking the decrease in the imports of ships as equivalent to a similar increase in exports, the net excess of increase of exports over imports is £4,676,758.

Market Prices for November.

Copper has been quiet on the whole, with tendency to rise about the middle of the month. Starting at £74.10 it had reached £77.10 by the 19th, and was over £78 on the 20th. On the 28th it only showed £77.15 and closes £76.10.0.

Tin opened at £229.5 and was fairly active, being at £229.15 at middle of month. A week later it was £227, and closes at £226.

Pig Iron (Scotch) has been quiet, with harder tendency towards the end of the month. Starting at 72/- it dipped a shilling on the 6th, recovering on the 7th. It commenced to rise on the 12th, and had reached 73/- by the 19th, and closes 73/10½d.

Cleveland has been in sympathy with Scotch pig, opening at 66/-, dropping on the 6th and rising on the 12th, it reached 67/9d. by the 28th, and closes at 67/2d.

Hematite has been slowly but steadily rising. Opening at 80/-, it reached 81/10 by the 19th, and closes at 82/-.

English Lead has fallen throughout November. Starting at £19.5, it was under £19 by the 5th, and continued to decline, reaching £18.15 on the 13th and £18.12.6 on the 21st. It closes at £18.10.0.

	£. s.d.
Aluminum, per ton	82 to 85. 0.0.
Alum, lump, loose, per ton	5.15.0.
Antimony, black sulphide powder, per ton	21. 0.0.
Borax, British Refined Crystal, per ton	17. 0.0.
Copper Ore, 10 to 25 per cent, per unit	14/- to 14.6
Copper Sulphate, per ton	25. 2.6.
Carbolic Acid, liquid 97/99 per cent, per gal	0. 1.5.
Creosote, ordinary good liquid, per gal	3.
Camphor, 1-oz. tablets	1.8.
Caustic Soda, Ash 48 per cent, ordinary, per ton	5.10.0.
Hydrochloric Acid, per cwt	5.0.
India Rubber, Para, fine, per lb	4.6.
Naphtha, solvent, 90 per cent, 160 degs. C., per gal	1.2.
Petroleum, Russian spot	8.
Quicksilver, per bottle	7.12.6.
Sal Ammoniac, lump, first, delivered U.K., per ton	44. 0.0.
Sulphate of Ammonia, f.o.b. Liverpool, per ton	13.17.6.
Sulphur, recovered, per ton	5. 5.0.
Shellac, Standard T. N. Orange Spots, per cwt	4. 4.0.
Tin Ore, 70 per cent, per ton	150 to 152. 0.0.
Zinc, Vielle Montague, per ton	30. 5.0.
Platinum, nominal, per oz	9. 5.0.

The differences on the month are thus:

Higher.

	£. s.d.
Antimony	1. 0.0.
Copper Ore	5½.
Carbolic Acid	1.
Camphor, oz.	¼.
Petroleum, gal.	¼.
Tin Ore	2. 0.0.
India Rubber	2.
Copper	1.10.0.
Hematite	2.0.
Scotch Pig	1.3½.
Cleveland	2.
Sulph. of Ammonia	9.6.

Lower.

	£. s. d.
Creosote, gal.	¼.
Quicksilver	7.6.
Zinc, V.M.	1. 5.0.
Tin	3. 5.0.
Lead	15.0.

London, England.

The Electric Furnace in the Production of Iron from Ore

A critical discussion of the present status and a comparison of the Scandinavian and Californian practices, by D. A. Lyon

AS is well known, the electric furnace, under favorable circumstances, may be used in the iron and steel industry for the production of metal from the ore, and later for the refining of this same metal into the grade of steel desired.

Conditions Favorable to the Use of the Electric Reduction Furnace.

It was pointed out by the Canadian Commission in their Report of 1904, that the prime pre-requisite for the use of the electric furnace in the reduction of iron ores, is cheap electric power. The large amount of experimental and practical work which has been done since that time has only emphasized this fact. The electric furnace, therefore, has not been developed as a competitor of the blast furnace, but, as is the case in Norway and Sweden, for the purpose of keeping alive an industry which finds itself confronted by conditions unfavorable to a continuation of blast furnace practice, due to the increased cost of charcoal; or for the purpose of making possible the development of the iron industry, as is the case in California, where the iron industry has never been developed, due to the cost in that section of the country of both charcoal and coke.

In each country, considerable experimental work was first done and then the furnace was tried out on a commercial scale. As was to be expected, the problems which presented themselves at the outset of the work were not solved at once, and there are still problems which are awaiting a more satisfactory solution than has so far been attained, but satisfactory progress is being made in this direction. That the electric iron ore reduction furnace has entirely passed the experimental stage is evidenced by the situation in California and Scandinavia.

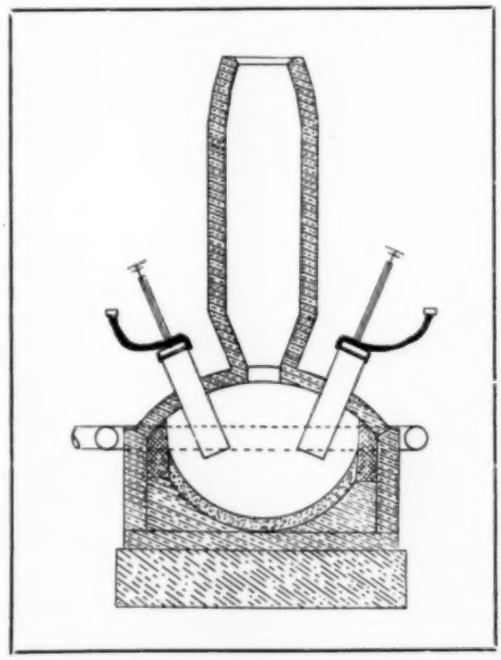

FIG. 1.—SECTIONAL ELEVATION OF TROLLHÄTTAN FURNACE.

The Scandinavian Practice.

Due to the large number of articles descriptive of the work in Sweden, which have previously appeared, it will not be necessary in this connection to do more than to refer to them and to state briefly the status of the electric reduction furnace in Scandinavia at present. (See also Oct. issue, 1911, p. 525.)

As a result of the successful operation of the furnace at Trollhättan, three other iron electric reduction furnaces are now being operated in Sweden[1] which together with the furnace at Trollhättan represent a total of 12,000 hp that is being used for electric reduction furnace work in that country; in Norway there is one 3500-hp furnace in operation and one 3500 hp and three 3000-hp furnaces in the course of construction, while in Switzerland one of 2500-hp is being built.

As was likewise pointed out in the September, 1912, number of this journal, the Uddleholms Company, at Hagfors, Sweden, are increasing their electric furnace installation by the addition of three more furnaces and will probably substitute electric smelting altogether for their blast furnace work. It is also a significant fact that the plant at Trollhättan, which was built by the Jern-Kontoret, of Sweden, purely for the purpose of determining the feasibility of attempting to reduce iron ores in an electric furnace, has been sold by the Jern-Kontoret to the Degerfors Iron Company, and will be worked by the latter company as a commercial proposition from now on. The Degerfors Company is an old-established company, who make very high-grade material, and so it is not a case of a new concern taking up with a new venture, but one with long experience in the business, who have had ample opportunity to carefully study the feasibility of electric reduction furnace work under the conditions prevalent in Sweden, and who, as a result of their study, have satisfied themselves that the electric furnace will meet their requirements. In fact, the old saying, "the proof of the pudding is the eating thereof," would seem to apply as regards the use of the electric reduction furnace in Sweden.

Some of the Difficulties That Had to Be Solved.

If a study be made of the drawings of those furnaces which have been tried out experimentally, it will be noted that in most of them an attempt was made to construct a furnace somewhat similar to a blast furnace, and to introduce the electrodes into the stack of this furnace at that point where the tuyeres are located in the former. All those who tried this soon learned that it was practically next to impossible to maintain the furnace walls adjacent to the electrodes. There was thus evolved as a matter of necessity the type of furnace construction which was finally adopted by the Swedish experimenters and such as is shown in Fig. 1[2]. By referring to the same it will be noted that the furnace consists of two separate parts, namely, the crucible or hearth, superimposed above which is a shaft or stack. One of the most serious difficulties that had to be overcome in the perfecting of the electric reduction furnace was the maintenance of the crucible walls and roof. Such a construction as shown in Fig. 1 solved the difficulty as it meets the

[1] A list of electric reduction furnaces now in use and in the course of construction in Europe will be found on page 539 of Vol. X of this Journal.

[2] Those caring for further information in regard to the work of the Swedish experimenters are referred to the article of Lars-Yngstom on "The Electric Shaft Furnace at Domnarfuet, Sweden," which appeared in this journal, Vol. VIII, page 11.

necessary pre-requisites, namely, keeping the end of the electrode dipping into the charge, as far removed from the side wall as possible, and second, keeping that part of the crucible out of contact with the charge at the point where the electrode enters the crucible. The reason for having to observe these precautions is due to the fact that the heat is excessive at that point where the electrode comes in contact with the charge, and hence this point should be as far removed as possible from both the side walls and roof of the crucible, in order to prevent the destruction of same through fusion.

The Electrode Problem.

When the demand was first made upon the manufacturers of electrodes for large electrodes of say 20 in. in cross section and 72 in. long, they experienced considerable difficulty in furnishing an electrode which would not go to pieces when put into commission. This caused considerable loss and annoyance to those attempting electric reduction and steel furnace work. Even if the electrode did not go to pieces, as soon as one-half to two-thirds of the same had been consumed it became too short for further use, and those unused portions represented a considerable item of expense. At the present time it is not only possible to obtain quite satisfactory electrodes, but also to

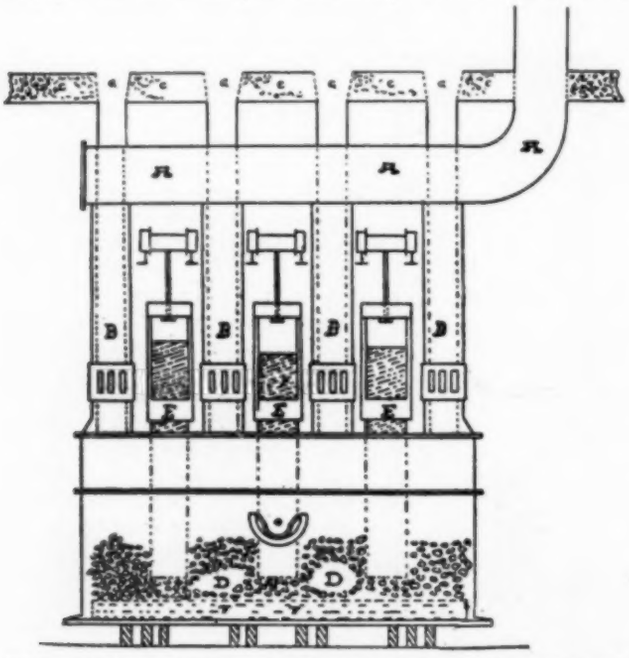

FIG. 2.—HEROULT THREE-PHASE FURNACE FOR SMELTING IRON ORE.

avoid the waste above mentioned. This is done by joining a new electrode to the butt end of an old one, as is done at Trollhättan[4] and at various other places.

So far our remarks have been applicable alike to the California practice and to the Scandinavian practice. It will, however, at this point, be necessary to discuss each practice separately, as they are at the present time radically different from each other. In order to understand the situation more clearly, it may perhaps be well to briefly outline the development of the electric reduction furnace as it has taken place in California.

The Development of the Electric Reduction Furnace in California.

For twenty-five years or more a company known as the Shasta Iron Company has owned a deposit of magnetite, located about seven miles from the mouth of the Pitt River, in Shasta County, California. This ore is a very pure magnetite, having on an average the following percentage composition:

Fe	69.90
(Fe_3O_4 89.4; Fe_2O_3 7.3)	
MgO	0.10
MnO	0.18
SiO_2	2.40
P	0.011
S	0.009

Although at one time or another the Shasta Iron Company has planned to make pig iron from this ore, nothing definite was done in regard to the same until the summer of 1906. At this time the possibility of smelting this ore by electricity was brought to the attention of Mr. H. H. Noble, president of the Northern California Power Company. Due to Dr. Heroult's connection with the experimental work which had been done at Saulte Ste. Marie, he was commissioned to construct a plant for the purpose of treating the ores above mentioned. The place selected was at a point on Pitt River, near the mines. This place was named Heroult and is still known by that name.

In July, 1907, the first furnace having been completed, experimental work was begun. This furnace was a 1500-kw, three-phase furnace of the resistance type. It was soon found that the type of furnace first used presented mechanical difficulties which made its commercial use impracticable, and so it was closed down. A sketch of this furnace is shown in Fig. 2. In construction the crucible resembled a long, elliptical-shaped iron box. The bottom was made of heavy cast-iron plates, into which had been cast cast-iron lugs or pins, and upon the iron plates was tamped a carbon bottom made of carbon paste. The bottom plates were connected with the bus bars in such a manner as to form a neutral in the three-phase system.

The electrodes passed through the roof, as shown in the sketch. They were suspended from copper holders which were water-jacketed. The charge was fed into the crucible through the pipe (*B*), and the gases from the crucibles passed up around (*B*) into (*A*), the idea being to thus preheat the charge in (*B*) by burning the gases around (*B*), air being admitted for that purpose through slots in the outer pipe just above the roof of the crucible. These pipes, however, proved too small, and the charge in them became so hot as to hang, and so they had to be done away with. It was also found impossible to maintain a roof over the crucible, and so the furnace was finally operated as an open-top furnace. Several tons of A No. 1 foundry iron were made in this furnace, and later it was used for making ferrosilicon, but was finally closed down and removed in order to make room for the type of furnace subsequently adopted. After the closing down of this furnace, experimental work was conducted in a 160-kw single-phase furnace, and from the results obtained in this furnace and its methods of operation a 1500-kw, three-phase furnace was designed and built. This furnace was practically the same in construction as is the furnace shown in Fig. 1. In other words, there was developed simultaneously in Sweden and in California a similar type of furnace, although neither the Swedish inventors nor those engaged in the work in California knew of the other's work. The development of this type of furnace was continued until the spring of 1911.[5] At that time, acting upon the advice of the consulting engineer then in the employ of the Noble Electric Steel Company, a radically different type of furnace was constructed. The object aimed at in the new design of furnace was to secure one which would be as easily controlled, so far as the regulation of the nature of the charge was concerned, as is the present open-hearth steel furnace. This furnace was not a success.

Another type was then hit upon, and this type has since been developed into a commercially successful furnace. It is shown in Fig. 3. By comparing Figs. 2 and 3 it will be seen that the furnaces shown in each are quite similar, but in a recent article descriptive of the plant of the Noble Electric Steel Company it is stated that "this resemblance is only general."

Electric Iron Reduction Furnace in California.

The following information in regard to this furnace and its operation has been furnished the writer by the secretary of the Noble Electric Steel Company, and is chiefly taken from a re-

[4] See this Journal, July, 1912, page 414.

[5] For account of the work done in this type of furnace in California, see this Journal, December, 1911, page 631.

cent article by R. W. Van Norden on "Electric Iron Smelting at Heroult, Cal."[*]

The furnace is housed in a heavy steel frame building, covered with corrugated-galvanized iron. It is rectangular in shape, 120 ft. long and 75 ft. wide, and has a height of about 60 ft. The building is in two sections or bays divided by a line of columns. The more southerly of these is the pouring floor, on which the pigs are cast. Throughout this bay is

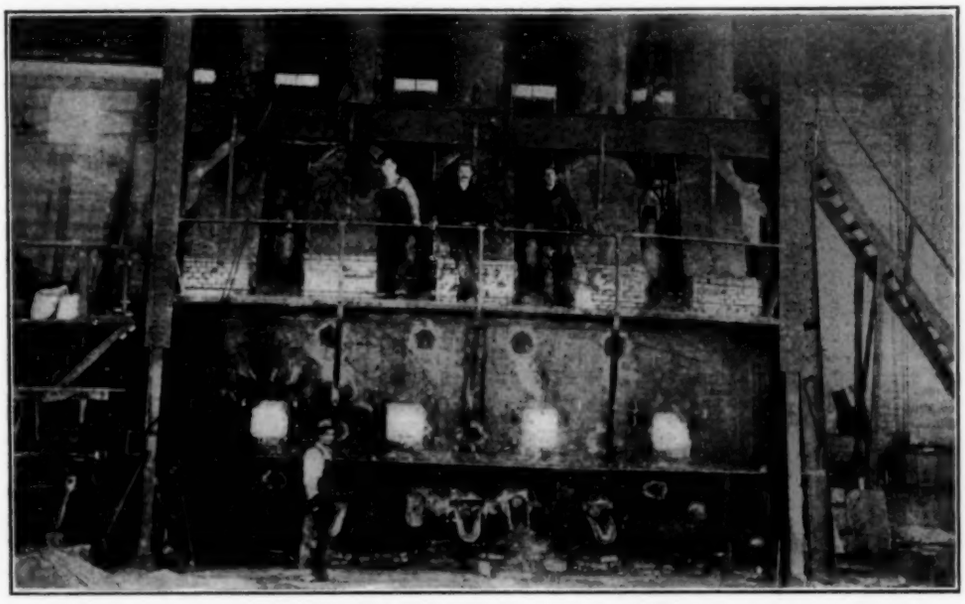

FIG. 3.—VIEW OF ELECTRIC IRON REDUCTION FURNACE AT HEROULT, CAL.

operated a 50-ft. Northern Engineering Company traveling crane. This is electrically operated and has two hoists, one of 20 and the other of 5-ton capacity. A Cleveland Electric Controller & Manufacturing Company lifting magnet, having a capacity of 2000 lb., is used in picking up the pigs. This magnet will lift about 1000 lb. of hot pigs.

The bay to the north of the center columns is given to the electric furnaces, their transformers and the necessary control. While but one furnace, having a capacity of 18 tons of pig iron per twenty-four hours is at present in use, two more of slightly greater capacity are practically completed. There is space reserved, and it is intended to immediately construct three more, thus bringing the total number of furnaces in this building to six.

The Furnace.

The crucible is contained in a steel shell 27 ft. long, 13 ft. wide and 12 ft. high. The shell is so lined with refractories that the upper half of the box is rectangular, but in the lower half the sides taper toward the center of the foundation, and the ends slope toward the middle to facilitate the flow of the molten bath, when the furnace is tapped. The tap hole is in the center and front of the crucible. The roof of the furnace is arched, and opening into the same are five stacks through which the charge is conducted into the crucible. In the four spaces between the stacks at the center of the dividing arches are inserted the graphite electrodes. The electrode jackets and the arched roof are water-cooled. The stacks or pipes through which the ore is charged are 24 in. in diameter and extend upward to a distance of 15 ft. from the roof of the crucible. These stacks are used only for the purpose of charging, no reduction being attempted in them. A charging platform is built along the top of the stacks and carries a track which runs to the mixing platform. Dump cars with the charge are run on the charging platform and dumped directly into the stacks. Except when receiving a charge, the stacks are closed with a tight-fitting cap.

[*]Reprint from Journal of Electricity, Power and Gas, Nov. 23, 1912.

The Electrodes.

Graphite electrodes are used. They are cylindrical in form, 12 in. in diameter and 4 ft. long. The upper end has a tapered male-threaded nipple, while the lower end has a corresponding socket with a female thread. As the electrode is fed into the charge a new one may be fastened to it, making a continuous feed.

An electrode lasts in continuous operation thirty days. Occasionally an electrode breaks in the furnace. This was formerly a serious matter and caused considerable delay and annoyance in the operation of the furnace. It was hard to determine just where the break had occurred, although it was generally at the threaded joint. A novel means has been devised by which the furnace men are now able to ascertain whether an electrode is broken or not. A bar is driven into the furnace opposite the electrode, through one of the several peep holes, and at the same time the electrode is tapped on top with a hammer. The man on the bar simply listens for the tapping. The tapping is then done on the bar and the man on the top listens. A break may be accurately located in this manner.

Transformers.

In the rear of each furnace, and as close thereto as is possible, are the three service transformers which supply three-phase current at from 40 to 80 volts to the electrodes. These transformers are oil-immersed and water-cooled and have a capacity each of 750 kw. The low-tension connections to the electrodes consist of eight pieces of flat copper bar, ⅜ in. thick and 5 in. wide, bolted together. On the 2400-volt primary side there are brought out eight current taps for voltage regulation.

These are taken to an oil-immersed, individual solenoid-operated switch group, which, with auto-transformer compensator, gives fifteen steps for voltage variation.

Electric Control.

Electric control is through a switchboard, there being a panel for each furnace. As the current and power-factor in each phase must be under observation at all times during operation, separate meters are installed in each phase. The requirements for one panel are three ammeters, three voltmeters, three wattmeters, three power-factor meters and three recording wattmeters. These are mounted across the panel in rows of three each. Under the first four sets named are three hand wheels to control the voltage variation, and under these three switches, which control the entire load, and still under these are the recording wattmeters.

For operating the voltage control and the main circuit breakers there is a 7½-kw. motor-generator set, comprising a 125-volt direct-current generator, directly connected to a 10-hp induction motor. This set has a small panelboard mounting a circuit breaker, ammeter, voltmeter, and two single-pole knife switches. The transformers, switches, and control were supplied by the General Electric Company. In the event that line voltage should fall, or for any other cause, the direct-current supply should become deranged there is a National Storage Battery Company's set, having a capacity of 7½ kw, which may be instantly switched in, and thus prevent the furnaces from cutting out in the case of low voltage.

Operation.

In operation the furnace is continuous. After a period of eight hours the hearth contains a full bath of molten metal, and this is, therefore, tapped three times each day. Charging is done at regular intervals and the current is not shut off at any time.

During the period of smelting the change in electrical conditions is interesting. At the beginning of the charge the power-factor is almost unity. This gradually lowers as smelting continues, until with a full bath of metal a power-factor of about 5 per cent is reached. If coke is used in place of charcoal, or if a mixture is employed a different set of power-factor conditions exists. By studying these conditions it is possible to know the exact condition of the charge by looking at the meters. The load is, of course, a function of the voltage, and with half voltage the load will drop one-quarter.

In charging, the ore cars are run on the mixing floor, which is at the same level as the charging floor. Cars with charcoal come into the lower part of the building and are hoisted on an electrically operated elevator to the mixing floor. Lime and quartz for flux are also brought in in cars, and each material is dumped into bins. The mixing is done in a car which is run on a platform scales. The charge is placed in layers, the proportions depending upon the tests made in the laboratory by the chemist. Following is a representative charge:

500 lb. iron ore (magnetite);
135 lb. to 150 lb. charcoal;
3½ lb. lime (well burned);
12½ lb. quartz.

Comparison of the California and Swedish Furnace and Process.

As to the construction of the two types of furnaces, the difference is so apparent that no comment is necessary. As to the process, the California practice differs from the Swedish practice very decidedly in the following respects, namely:

1. No attempt at reduction in the stacks of the furnace.
2. Non-circulation of gases.
3. The use of limestone calcined outside the furnace.

In other words, the California practice is just the reverse of the Swedish practice, for in the latter they attempt reduction of the ore in the shaft of the furnace, they circulate a part of the gases escaping from the top of the shaft, and they do not use burned limestone.

Reduction in Shaft.

It would seem that the ideal condition in electric reduction furnace work would be to have the charge in such a condition as to only require melting by the time it comes in proximity to the electrodes. If this be done, the electric current is then only called upon to furnish the additional heat necessary to bring about the melting of the hot, previously reduced oxide. Of course, the heat for the reduction must come from some source, and its origin would be in the crucible and as a result of the heat developed during the melting of the charge, but, as will be stated presently, the excess heat so developed can be transferred by the circulation of the gas to the charge in the shaft and not carried away by radiation and an excessive amount of cooling water.

Gas Circulation.

In the Swedish practice, a portion of the gases rising from the top of the shaft are returned to the crucible and made to pass through the same and up through the charge in the shaft. This is done for the following reasons:

1. To cool the superheated brickwork.
2. To carry up through the stack a sufficiently large volume of gas which has been raised to a high enough temperature to bring about reduction in the stack.

As has been previously pointed out in this article, one of the most serious difficulties that had to be overcome in the development of the Swedish type of furnace was the destruction of the crucible due to local heating in the vicinity of the electrodes. Therefore by returning to the crucible a portion of the gases resulting from the reduction of the ore, it is possible to prevent excessive local heating and at the same time to make use of the heat instead of wasting it. This matter has been the subject of much discussion,[1] and has its objections, but the writer is of the opinion that its advantages in the way of economy of operation far outweigh its disadvantages. Perhaps it will in time be found practical not to use gas circulation in the electric iron reduction furnace, but, on the other hand, we believe that reduction previous to melting will be considered the proper practice, which means stack reduction, and the present California practice will not find application except in those instances where the local conditions warrant the same, as is the case at present. As has been pointed out, the present demand in California is for a soft grey foundry iron. The furnace now used gives that product, but this does not mean that such a construction and such a process are absolutely necessary for the production of such an iron. As a matter of fact, many tons of the same kind of iron were made at Heroult in a furnace of the Swedish type, and the Swedish inventors claim that it is possible to operate their type of furnace so as to reduce regularly an iron of the same character as is now produced at Heroult. They state, however, that in operating the furnace for this purpose the amount of electrical energy consumed per ton of pig produced is increased.

As to why the California type of furnace is better suited to the production of a soft grey foundry iron than is the Swedish type of furnace, it is probably due to the fact that reduction is performed solely by solid carbon in the crucible and as silicon is only reduced by solid carbon, its reduction to silicon takes place at the same time as that of iron oxide to metallic iron. The silicon is dissolved in the iron and by its presence causes the carbon to precipitate out as graphitic carbon, and there is thus obtained the soft grey iron desired. We are also of the opinion that in a furnace having a rectangular-shaped crucible, such as has the California furnace, the temperature of the charge in the crucible as a whole is much higher than is the case in a furnace of the Swedish type, and this higher temperature is more favorable to the reduction of silica to silicon, the latter, as before stated, being largely the controlling element in the production of soft grey foundry iron.

The Use of Calcined Limestone.

This has been repeatedly suggested, and theoretically it is the proper thing to do, but when operating a furnace of the Swedish type there are two objections to its use, namely:

1. It increases the percentage of fines in the charge.
2. It makes the charge hang.

As to the former of these objections, the idea seems to be more or less prevalent that there is no limit to the percentage of fines that may be used in the electric reduction furnace. We are not definitely informed in regard to this point with reference to the California practice, but judging from observations made upon the smelting of black sands, when the furnace consisted simply of a crucible and no shaft, more or less difficulty was experienced on account of the charge being made up entirely of fines. In the Swedish practice, the matter of the proportion of fines that can be used in a charge was definitely determined in the work at Trollhattän, and it was found that a large proportion of fines was detrimental to smooth running and good results, but Mr. Leffler, one of the engineers in charge of the work at Trollhattän, states that he is of the opinion that calcined limestone may be advantageously added to the charge if no reduction is attempted in the shaft.

Summarized, then, we may say that the California practice as compared to the Swedish practice presents the following advantages:

1. Permits the use of limestone calcined outside the furnace.
2. Does not require the circulation of gases.

As to this latter point, and also as to reduction in the shaft, we are not sure but what the California practice would prove more efficient if both were done. Although a very full and

[1] "Gas Circulation in Electrical Reduction Furnaces," J. W. Richards, Transactions, American Electrochemical Society, Vol. XXI, page 403.

complete record of the working of the furnace at Trollhattän has been published, such is not the case as regards the operation of the furnace at Heroult, and so it will not be possible to make a definite comparison of the two practices until it is posssible to receive as definite information in regard to the working of the furnace at Heroult as is now available in regard to the operation of the furnace at Trollhättan.

Lines Along Which the Electric Furnace Will Probably Be Improved.

The Size of the Unit.—In Scandinavia the furnace has gradually been increased in size until now there are 3000-hp furnaces in operation and A. B. Elektrometall have completed a design for a 7500-kw furnace. Naturally the problem in connection with a furnace of the Swedish type is to get such an arrangement of the electrodes as to insure a practical uniform heating of the whole contents of the crucible, and at the same time maintain the electrical equilibrium of the power system.

It is quite certain that the Swedish type of furnace will be improved along this line, namely, increase in size of the unit, and it is for this reason that results obtained from the operation of a furnace designed for 7500 kw will be awaited with great interest.

As for the California type of furnace, it will no doubt be possible to indefinitely increase the length of the same, just as has been done with the modern rectangular copper blast furnaces.

Efficiency.

The efficiency of the furnace will also be increased as time goes on, and probably by improvements along the following lines:

(a) The utilization of the waste gases.
(b) The securing of a high power-factor.
(c) The correction of induction losses.
(d) The further study of the single-phase furnace vs. the three-phase furnace.

As regards the latter, inasmuch as practically all large power installations are three-phase, it would seem that the only logical thing to do is to use three-phase current in electric furnace work, but from data submitted by Catania it would seem as if the mono-phase furnace is more efficient than the poly-phase furnace.

Summary.

Summarized then, we may say that the electric iron reduction furnace has passed the experimental stage; that it is meeting the requirements in those localities where it has been introduced, and that it will no doubt find extended application in those countries where the conditions are favorable to its introduction, namely, where electric power is comparatively cheap and where coke and charcoal are comparatively high. Inasmuch as the cost of electric power is largely the governing factor in determining its adoption, and as the cost of electric power is constantly decreasing, we may expect to find an extended application of the electric reduction furnace in the future.

Pittsburgh, Pa.

Bakelite Billiard Balls.—Another milestone has been reached in the victorious course of bakelite in its introduction into the most varied industries by the invention of the bakelite billiard ball. Ivory lacks uniformity and is seriously affected by changes in temperature and climate. As a result of years of scientific experiment a composition ball has now been perfected which is of the same weight and resiliency as the best ivory ball, but practically indestructible and absolutely unaffected by heat or cold, dryness or dampness. This composition ball is the invention of Mr. J. W. Hyatt (the inventor of celluloid) in co-operation with Mr. Charles F. Burroughs. The basic material of this ball is bakelite, Dr. L. H. Baekeland's well-known invention. The bakelite ball is made by the Hyatt-Burroughs Billiard Ball Company, 141 Commerce street, Newark, N. J.

The Billiter Alkali-Chlorine Cells.[1]

By A. J. Allmand, D.Sc.

The most important advances made in late years in the technical electrolysis of alkaline chlorides for the production of caustic alkali and chlorine are perhaps due to Dr. Jean Billiter, privatdozent in the University of Vienna. Some years back he designed a diaphragm cell which is being exploited by Siemens & Halske, and recently he has invented a modified form of the well-known bell-jar cell, which is undoubtedly, taken all in all, one of the most efficient cells now operated technically. The Billiter-Siemens diaphragm cell I propose to mention briefly only, as full accounts of it are available elsewhere,[2] and shall devote most attention to the Billiter "membrane" cell, the first installation of which started work early this year.

Billiter-Siemens Cell.

Most diaphragm cells in technical use have vertical diaphragms (e. g., Hargreaves-Bird, Townsend, Finlay). Billiter, however, has returned to the use of horizontal diaphragms such as were formerly employed by Le Sueur and by Carmichael. He has compared elsewhere the relative advantages and disadvantages of the vertical and horizontal arrangements.

A horizontal diaphragm is more slowly attacked chemically, as it remains more or less saturated with the alkali which migrates upwards from the cathode situated immediately underneath. This is particularly important when making strong alkaline liquors. Further, the hydrostatic pressure on it is uniform at all points, not varying with the height as in vertical diaphragms. This means a more uniform flow of liquid through, and consequently a more efficient checking of the movement of the OH^1 ions towards the anode.

There are corresponding structural disadvantages. The floor-space needed is greater. Further, the insides of the cells are less easily accessible and the anodes are necessarily of more complicated construction.

The active diaphragm material in the Billiter-Siemens cell consists of a mixture of asbestos wool and $BaSO_4$, spread out evenly on top of a sheet of woven asbestos cloth, which in its turn rests on the iron-wire net-work which constitutes the cathode. The function of the asbestos cloth is merely to support the $BaSO_4$ mixture and to prevent its being displaced by the lively hydrogen evolution. The cathode makes contact with the iron bottom of a trough, the sides of which are lined with cement, and the anode chamber is formed by a non-conducting bell-jar which is securely cemented around the edges of the diaphragm. An important feature of the cell is the arrangement for heating the electrolyte by means of earthenware pipes through which hot liquids run, these being immersed in the brine at the top of the bell-jars.

Cells have been made carrying up to 3,000 amperes at a current density of 4-6 amp. per sq. dm. Working at 85-90 deg., 12-16 per cent. NaOH or 18-20 per cent KOH can be made at a 95 per cent cathodic current efficiency, employing 3.5 volts.

An interesting laboratory study of the Billiter-Siemens cell has been recently published by Mühlhaus.[3] He finds that the $BaSO_4$ used for the diaphragm is best precipitated hot. No change of size of grain when in the hot liquors of the Billiter cell is then likely to take place, and a regular and uniform liquid flow is thus assured.

The highest current density permissible is about 6-7 amp. per sq. dm.

Above this limit, disintegration sets in. Using 30-32 per cent brine at ordinary temperatures, the following figures were obtained:

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[1]A paper read before the Faraday Society in London on November 26, 1912.

[2]Billiter, Die elektrochemischen Verfahren der chemischen Gross-Industrie, ii., 215 ff. Die electrolytische Alkalichloridzerlegung mit starren Metallkathoden, i., 119,191. See also Allmand, Principles of Applied Electrochemistry, p. 375. Also Chemiker-Zeitung, 1911, p. 573; Der Papier Fabrikant, 1911, Parts 1, 11, 33; Wochenblatt für Papierfabrikation, 1911, Parts 19, 42.

[3]Dissertation (Dresden, 1911).

Concentration of Alkali.	Current Efficiency. Per Cent.
3n.	98-99
4n.	95-97
5n.	80-85
6n.	75

The chlorine gas fell in purity from 99.5 per cent to 92 per cent as the alkali concentration was increased. The oxygen produced exceeded the amount of CO_2. The solid caustic resulting contained considerable quantities of $NaClO_3$ if produced from liquors stronger than 4n. The best results on the whole were given when making 4n. NaOH at a current density of 4 amp. per sq. dm. Raising the working temperature to 70-80 deg. improved both energy efficiency and purity of alkali.

The Billiter-Siemens process is now operated as follows:

(*a*) In Aschersleben, Saxony, by the Kaliwerke Aschersleben A.G. Ten 2,000-ampere units.

(*b*) In Höchst, by the Farbwerke Höchst.

(*c*) In Brückl, Bosnia, by the Bosnische Elektrizitäts A.G. Sixty-four 2,500-ampere units.

(*d*) In Krumau, Bohemia, by Ignaz Spiro und Söhne. Thirty-two 500-ampere units.

(*e*) At Niagara Falls, by the Niagara Alkali Company. A 1,000-kw installation of 3,000-ampere units.

A number of plants are also being installed or enlarged. The Niagara Alkali Company (which has succeeded the old Roberts Chemical Company), is at present increasing the size of its plant from 1,000 to 3,000 kw. It has also been made known that a new factory for caustic alkali and bleach is being erected, commencing with 78 2,000-ampere units, and that a textile factory is installing 24 100-ampere units.

Billiter-Leykam Cell.

In this cell[4] Billiter has successfully modified the bell-jar process, placing the cathodes (hooded to collect the hydrogen) immediately *underneath* the bell-jar, and not around its sides, as in the Aussig cell. Similar constructions had been formerly suggested by Richardson[5] and by Bein,[6] but had achieved no technical success.

By doing this, Billiter gains an important advantage. In the ordinary bell-jar cell, both flow of liquid and flow of current change in direction at the lower edge of the bell-jar. This results in non-uniformity of current density and liquid flow in the different parts of the bell-jar section. At some points liquid will be flowing more quickly than is necessary to overcome the OH′ migration towards the anode, at other points the contrary will be true; the movement of the OH′ ions will predominate, and the current efficiency will fall. This last statement particularly holds for those parts of the bell-jar section furthest removed from the walls, where the current of liquid is exceedingly slow. The larger the bell-jar, the greater proportionately is this disturbance. It also increases rapidly with current density. The consequence is that the units (bell-jars) at Aussig are very small, and can only be worked at a low current density, furnishing weak alkali. Such a plant requires much floor space for its output and the labor charges are high.

In the Billiter cell, this change of direction and the resulting irregularities are avoided, the motion of the brine being directly opposed to that of the current lines until it has passed the cathodes. The consequence is that high current densities can be used, stronger caustic liquors produced, high current efficiencies obtained, and large units constructed. At the same time, the advantage of the bell-jar cell—the absence of diaphragms—is essentially retained. For, though the *current* must all pass through the hoods which cover the cathodes, this is not true of the electrolyte. Most of it passes directly through the spaces between neighboring cathodes, and is charged with caustic by diffusion from the concentrated alkali which fills the cathode hoods. Not only does this alkali protect the hood material (in practice, woven asbestos) against chemical action of chlorine compounds, but suspended matter present in the brine is not filtered out, as happens in diaphragm cells, and it is not necessary to purify the brine in any way. The asbestos hoods are made of as coarse a structure as is consistent with their function of leading off the hydrogen gas, and affect the voltage to a very slight degree only. Finally, the cell is heated in a similar fashion to the Billiter-Siemens cell, and the voltage thus lowered.

The essential parts of the Billiter-Leykam cell are shown diagrammatically in Figs. 1 and 2. A is the bell-jar inverted in the cement trough B, and provided with anode outlet for chlorine, inlet for brine and heating arrangement (not shown). The cathodes C are arranged below the bottom level of A and consist in practice of T-iron. They are enclosed separately in long woven asbestos tubes which are suitably braced in order to avoid deformation by the evolved hydrogen, and are slanted sufficiently to allow the gas to stream away readily. These cathodes project out into a side compartment of the cell as shown, from which the hydrogen can, if necessary, be collected.

The causticised brine flows off through D.

The Austrian rights to the Billiter bell-jar cell have been purchased by the paper manufacturers Leykam-Josefsthal A. G. The first plant has been erected in their factory at Gratwein, a village on the Austrian Southern Railway, a few miles from Graz, has been in continued operation since early 1912, and has given every satisfaction. Some 1,700 to 1,800 kilos of active chlorine are produced daily, and the whole plant uses about 400 P. S.[7]—350 P. S. for the cells and 50 P. S. for auxiliary pumps, fan, etc. Power is purchased from a company at 150 kr. ($31.25) per P. S. year. After converting into direct current, and reckoning all losses in leads, etc., the cost comes to 180 kr. ($37.50) per P. S. year.

The plant consists of 561,200-ampere units, 50 of which were working at the time of my visit last July. The cells are 5′5 metres long, 1′1 metres broad (internal measurements), and about 1′3 metres high. The side walls commence to slope inwards about 70 cm. below the top of the cell. They are built of reinforced concrete, the upper part being lined with earthenware bricks set in cement.

They are provided with three cement lids, each of which cement lids, each of which carries eight anodes.

The anodes are of Acheson graphite (1′0 x 0′18 x 0′05 metre), each being led through its lead by means of two graphite rods. The lids are cemented on to a shallow shelf cut out of the wall of the cell by means of ordinary putty, which stands the action of chlorine very well and always remains fairly soft. Putty is also used at the points where the anodes pass through the lids, as the weight of the anodes is not borne by the latter, but by the copper leads above. Each anode takes 50 amperes at a current density, assuming lower and side surfaces to be active, of about 1′6-1′7 amp. per sq. dm.

The cathodes are of T-iron and enclosed in woven asbestos tubes. These taper down slightly towards their closed lower ends, and the whole is braced by the insertion of a wedge-shaped strip of asbestos cement. The tubes pass through holes in the dividing wall into the side compartment of the cell as indicated in Fig. 1. Two iron rods attached to each T-iron cathode take the current to the copper leads above. The hydrogen is allowed to escape. The cathodes are, of course, about 1 metre in length, and the mean breadth of the asbestos tubes is about 5 cm. Between each tube there is a space of 5 to 8 mm. The upward slope of these tubes is about 2 cm. per metre.

The brine (moving from a reservoir under gravity) is led to a distributing box situated above the cell. From this it proceeds by way of a series of short capillary tubes (1.5 mm. bore) to 22-in. tubes, which pass through the cell lids, and is

[4] British Patent, 11,693 (1910); Principles of Applied Electrochemistry, p. 373.

[5] British Patent, 5,694 (1893).

[6] British Patent, 24,058 (1899).

[7] The P. S. (Pferde Stärke or German Horse Power) and P. S. year are of course about 1½ per cent. smaller than the corresponding H. P. and H. P. year units.

thus fed in between the anodes. Regulation of the main supply to the cell is effected by means of a rubber tube and clip. This arrangement acts on the whole very satisfactorily, though the capillaries sometimes get stopped up. The causticised brine is drawn off from one side of the cell by means of siphon overflows. Three are provided, but one only is used in practice.

The heating arrangement used by Dr. Billiter in his diaphragm cell, though available for all other installations of his "membrane" cell, cannot* be used at Gratwein. The cells are, therefore, provided with a heating arrangement which employs steam, the details of which, however, I cannot divulge here. When I was at Gratwein the cells were being mostly worked at room temperature, whilst those few which were being heated were working at 65 deg. to 70 deg. The cost of the steam used is very small.

The cells are arranged in four rows, two rows being worked in series, and are insulated by glass resting on concrete supports. Beneath the cells are arranged the chlorine and brine pipes, and a channel for the caustic liquors. The chlorine pipe-line is constructed of cement, junctions being made by covering the ends with a cement box and filling up with as-

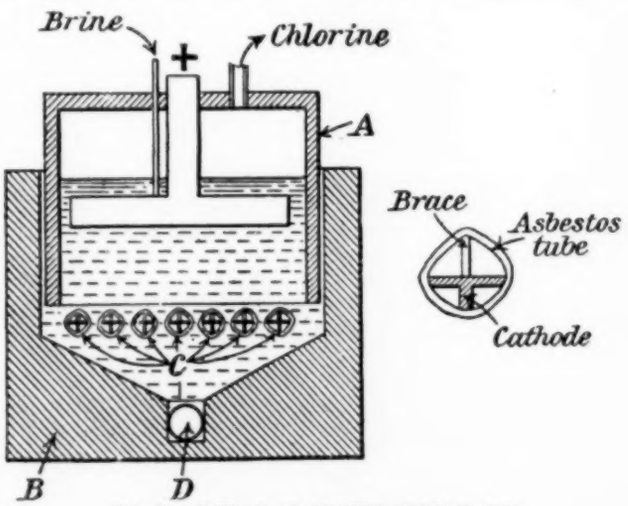


FIG. 1.—SECTION OF BILLITER-LEYKAM CELL

phalt. The current leads are of copper, those connecting the cells of circular cross-section and 3 cm. in diameter. They are all painted with a composition stable against chlorine and acid fumes, as are also the tin tubes and rubber connections referred to above. The cells are worked under slightly reduced pressure (½ cm. of water), and, as a matter of fact, no smell of chlorine was noticeable. Ventilation can be effected, if necessary, by blowing air in through the agency of a fan driven by a horse-power motor. A traveling-crane is provided to facilitate lifting off the tops of cells, etc.

Saturated brine is used, prepared in the simplest way. A long cement trough is filled with large lumps (20-40 cm.) of crude salt. Water enters continuously at one end, and saturated brine leaves at the other. It is not purified, and can be sent straight to the cells. The average cathode liquors produced contain 12-13 per cent NaOH and about 20 per cent NaCl. By decreasing the rate of flow of brine, 16 per cent NaOH can readily be made. Up to 350 litres of brine per cell are causticised in 24 hours. The liquors are first evaporated in two vacuum pans, furnished by the Skodawerke A.G., Pilsen, and similar to those used in sugar refineries. In these they are successively brought to 30 deg. and 40 deg. B. Then by means of a Kaufmann rapid evaporator they are brought to 50 deg. B before going to the melting-house. The final product, which will probably be later somewhat improved upon, contains 97 per cent NaOH, 1.2 per cent Na_2CO_3, and 1.8 per cent NaCl. The chlorine is diluted and absorbed in milk of lime.

*The patent rights are not there available.

Cells which are worked at room temperature take about 4 volts. Those I saw working at 65-70 deg. require 3.4-3.5 volts. Long continued experiments carried out with a 250-ampere unit have shown that at the normal working temperature of 85 deg. the voltage falls to 3.1 volts (*plus* in all cases the voltage drop in the leads). The cathodic current efficiency is about 92 per cent for 3n-4n alkali.

It remains to be added that wear and tear in the cells are very small. Under normal working conditions the anodes lose about 1 mm. in thickness at their bottoms and sides in two months. Suspended matter in the brine settles on the bottom of the cells, and the asbestos hoods remain unaffected. Finally, when once matters are adjusted, the whole system works automatically. The actual cell-room in Gratwein is worked by shifts of one workman only, whose duty it is to adjust the rates of flow in the different cells. Moderate fluctuations in rate of flow of brine or in current density result in a change in the alkalinity of the liquors produced, and in a corresponding *small* change in current efficiency. The cells at Gratwein work at a current density between the electrodes of about 2 amp. per sq. dm. only. With cells working at 85 deg. the most convenient figure, according to Billiter, is 4 to 6 amp. per sq. dm.; but, by suitably varying the other conditions, 14 amp. per sq. dm. can be employed.

The withdrawal of 350 litres of catholyte per cell per 24 hours corresponds to a movement of the brine of about 0.00007 cm. per second. The OH' ions in that part of the catholyte between the electrodes will have a velocity anodewards of just about the same magnitude. (*E.g.*, assuming the cell to work at room temperature, the conductivity of the electrolyte would be about 0.5 recip. ohm per cu. cm., the velocity of the OH' ion at a voltage gradient of 1 volt per cm., 0.0018 cm. per sec., and the actual velocity $0.02 \times 0.0018 \div 0.5 = 0.000072$ cm. per sec. This close approximation between the two opposing velocities, with the consequent straying of OH' ions towards the anode, is of course the chief cause of the 8 per cent deficiency in cur-

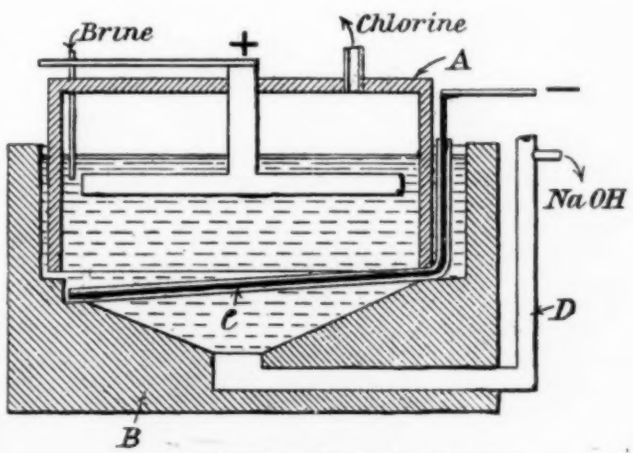


FIG. 2.—SECTION OF BILLITER-LEYKAM CELL.

rent efficiency, as the amount of chlorine which dissolves in the concentrated brine, and which would thus tend to be carried to the cathode, is very small.

The second installation of the Billiter membrane cell is at the present time being erected in Saxony.

In conclusion, I will again emphasize the chief characteristics of the Billiter-Leykam cell. They are—

(1) Freedom from diaphragm troubles.

(2) Use of impure brine.

(3) Automatic working, great adaptability, and low attendance charges.

(4) Alkali (3n-4n) strong compared with most other non-mercury cells.

(5) With heated cells, lowest energy consumption per ton of product of any of the electrolytic cells now working on a large scale.

Concentration of Scheelite.

There is but one commercially important deposit of scheelite in Canada. It lies in the central part of Halifax county, Nova Scotia, 12 miles from the Atlantic coast and 34 miles from the nearest railroad point. It is 2 miles west of the old Moose River gold mines. The ore consists of quartz, scheelite, ankerite and arsenopyrite. Not a particle of either of the black tungsten ores[1] has ever been found with the scheelite. In a paper read before the Colorado Scientific Society by **Victor G. Hills,** the method of concentrating this ore is described, as follows:

Construction and Operation of Mill.

On March 1, 1911, I took charge of the property to develop the mines and build a mill. Foundations for boilers and air-compressor were begun by blasting in frozen ground. The lumber for building was made with a portable saw-mill from trees cut in the nearby woods. There was neither clay nor sand for brick, mortar, or concrete. Brick was hauled in on sleighs at a cost of $30 per thousand; also some sand was hauled 18 miles by sleighs. Later, when the river was clear of ice, sand was made out of quartzite boulders by crushing in an old water-power gold stamp-mill found 2 miles distant. A wagon road had to be built into the camp when the ground was thawed out enough to permit it. The best English Portland cement and Scotch fire-brick were readily obtainable at Halifax, but the 34 mile wagon haul for these things and for the machinery made construction tedious and slow, and the year 1911 was consumed before the mill began producing concentrate.

A modest but substantial mill was built to treat one ton of crude ore per hour. I outlined a flow-sheet to take advantage of every inexpensive device to prevent sliming. The ore was dumped over a grizzly before going to the crusher. The roll feed was washed by a spray so that only the clean coarse material went to the coarse rolls. Rolls were used for crushing, as being undoubtedly better than stamps or any other form of screen-faced pulverizing mill to avoid sliming.

While the scheelite is more friable than either the quartz or the ankerite and, as usual in the concentration of all tungsten ores, the main loss is in the slime tailing, yet this loss with scheelite is somewhat less than with our Colorado black ores. The walls of the vein are slate which makes an enormous amount of slime and augments the difficulties of handling this portion of the pulp. This must be remembered when considering the loss in slime tailing.

In milling, since scheelite and mispickel have the same specific gravity—6.0—they together form the concentrate from the tables. The pyrite is just enough lighter to enable it, for the most part, to be thrown out with the tailing.

The raw concentrate consists of some 45 per cent mispickel coming partly from the vein and partly from the slate wall-rock. To get rid of the arsenic it was necessary to roast and treat with a magnetic separator. This phase of tungsten milling, of course, does not appear in our Colorado work.

Roasting for Magnetic Separation.

For roasting a Wilfley revolving hearth furnace was built. It proved quite satisfactory. For treating separately numerous small lots of both coarse and fine material, and particularly where the furnace can not be kept in steady operation, I know of no roaster that would be more desirable. The literature on the subject of ore-roasting seems to be notoriously meager in reference to the degree of heat used in connection with the time of exposure. I found that this mispickel was decidedly better prepared for the magnetic separator by a high temperature and short exposure. Thus, 1500 deg. F., for 50 seconds gave better results, for example, than 1100 deg. for 90 seconds. The tests which had been made on roasting this ore at the Kingston School of Mines had evidently proceeded on the idea of burning off as much of the arsenic as possible; but this idea was all wrong. The best separation of the arsenic can be made by the least possible roasting that will render the iron magnetic. The arsenic can then be removed with the iron.

A Dings single-magnet separator made an excellent, clean separation. The magnetic part carried an average of 0.72 per cent WO_3, with some lots as low as 0.42 per cent. The non-magnetic product carried only 0.34 per cent arsenic. And these returns could, if necessary, be further reduced by using a two magnet separator or by running through a second time. The separator operated at 8 amp.

The finished product carried, besides the 0.34 per cent arsenic, a little sulphur and phosphorus. Otherwise the concentrate contained no deleterious element. While no other tungsten ore in the world compares with our Colorado product for freedom from undesirable elements, this Nova Scotia product is quite within the general market requirements and compares favorably with the tungsten ores from most parts of the world.

With my trial run the mill saving was 86.8 per cent. Remembering that, besides the excessive amount of scaly slate gangue, augmenting the slime loss, this concentrate has to be subjected to a second loss from flue dust in roasting and a third loss from magnetic separation, I regard this as a good saving. The market product carried 70 per cent WO_3. That this is higher than the average of our Boulder county product is, of course, due to the higher tungstic acid content of the lime tungstate. The coarser table products at Scheelite would run as high as 73 per cent WO_3. A test on this ore made at the Kingston School of Mines reported a saving of 89.5 per cent; but the ore was sorted nearly free from slate and the method used was impracticable to apply in a small and simple mill. Additional mill equipment, introducing coarse jigs, regrinding of middlings, and more slime-settling capacity, would materially increase the saving. It is the old mill problem; to determine whether the additional saving would pay for the outlay necessary to produce it.

[1]Milling practice on Colorado tungsten ores was described in this journal, July and August, 1911.

Production of Copper and Nickel in the Electric Furnace.

At the first general meeting of the recently formed "Gesellschaft Deutscher Metallhütten und Bergleute" (Society of German Metallurgical Engineers, essentially restricted in its scope to non-ferrous metallurgy), Mr. **M. Stephan** gave an account of some experiments made by him on electric smelting in non-ferrous metallurgy. Mr. Stephan is the superintendent of the Girod electric steel works in Ugine, which are familiar to our readers from previous descriptions.

Copper.—Formerly the Keller-Leleux Company, of Livet, France, have experimented with a Chilenian copper sulfide ore containing 5.1 per cent Cu producing a matte of 40 per cent to 50 per cent Cu and a slag with 0.1 per cent Cu. The problem brought before the Society An. Electrometallurgique Procedés Paul Girod was to reduce a copper oxide ore in the electric furnace by means of solid carbon as reducing agent and with a certain limestone as flux.

The ore came from the Belgian Congo, being mined by a Belgian-English concern. In five different analyses given the CuO varies from 21.01 per cent to 5.73 per cent, SiO_2 from 28.48 per cent to 78.55 per cent, with from 4 to 13 per cent Al_2O_3 from 4 to 16 per cent Fe_2O_3, and besides smaller impurities from 2 to 7 per cent CoO, no nickel.

The moisture in the ore varied from 7 per cent to 32 per cent. It was not removed in order to meet the conditions of practical operation and to carry the experiments out under most unfavorable conditions.

Charcoal, coke, and anthracite were used successfully as reducing agents. Charcoal will probably be the cheapest under the special circumstances. Electrodes were primarily carbons of Girod's own make, and also bottom electrodes of soft steel or water-cooled copper; 500 kw were available for the experiments, for which not over 200 kw were used at from 30 to 150 volts.

Ores of the kind described are difficult to work with in the

water-jacketed copper blast-furnace. They do not offer any trouble, however, in the electric furnace. Within the limits of the highly refractory furnace lining it is possible to regulate the temperature, viscosity and composition of the slag to suit any condition.

Electric furnaces similar to the Girod steel furnace type were used and dimensions changed in several runs within wide limits in order to secure enough data for the construction of a large furnace for the same work. Electrodes were used suspended from the top and inserted in the bottom, also in the sides for heating by radiation, and a system was adopted of heating with a smothered arc mainly by the resistance of a thick layer of slag over the conducting metallic charge. The temperatures were measured with LeChatelier, Wanner, and Fery pyrometers.

A slag of the composition

SiO_2	Al_2O_3	CaO	MgO	Fe_2O_3	MnO	CuO	CoO
51.90	11.31	16.83	13.71	3.55	0.94	0.46	0.87

begins to melt at 1250 deg., begins to flow in a pasty condition at 1350 deg., and is liquid enough at 1400 deg. to allow the little copper balls to completely settle. At 1550 deg. the slag is liquid enough to flow off freely; 1920 deg. were necessary to render the slag liquid when the highly acid ore was smelted without any fluxes.

The pig copper (Schwarzkupfer) produced analyzed in six different runs from 65 per cent to 95 per cent Cu, containing from 1 to 21 per cent Fe and from 1 to 11 per cent Co. The purity of the product will be the higher the lower the melting temperature.

The lower the temperature the smaller will be the chance for reducing any of its impurities, but at the same time more copper will also be retained in the slag so that the output is decreased.

It will be a matter of commercial calculation, according to the composition of the ore and other special conditions, whether a high-quality product or a maximum output will be desirable.

A continuous run for several days with the same ore aiming at slags of about the above mentioned composition required 1000 to 1200 kilowatt hours per ton (of 2205 lbs.) of ore.

These figures are high, as a result of the amount of heat required to keep the very viscous and anomalous slags in liquid condition.

With an easily fluxible ore the specific power consumption was only about 500 kilowatt hours.

The electrode consumption averaged 8 kg. or 17.6 lbs. per ton of ore, using an electrode of 1.8 specific density and 3500 microhm resistivity (per sq. cm section and cm length); it was operated with 4 amperes per sq. cm (25.8 amperes per sq. inch).

Coal for reduction was used at the rate of 25 per cent of the copper in the charge.

The best lining to withstand the severe conditions of the furnace was tamped from fire-clay with 80 per cent SiO_2 and 15 per cent Al_2O_3.

Nickel.—While in older experiments of his firm and in the experiments described in the paper read by Walter Morrison before the American Electrochemical Society last year the product was a nickel with high Si contents, Mr. Stephan was able to obtain a ferro-nickel with only 3 per cent to 5 per cent Si, as for instance:

Ni	Fe	Si	Al	C	S
41.50	51.61	4.33	0.81	1.34	0.04 per cent

from an ore containing 8.33 per cent NiO. A small furnace of 220 kilowatt treated 3 tons of ore in 28 hours and produced 350 kg. of metal. From this the author concludes that on a commercial scale the specific power consumption would easily be reduced to 1200 kilowatt hours per ton of ore and that the electrothermic smelting of nickel ores will pay in districts when power is cheap.

The complete paper by Mr. Stephan may be found in *Metall und Erz*, vol. 10, pp. 11-17 and 84 to 86, 1912.

Wood Waste Utilization.

The Industry in Its Relation to Expert Advice.

By John E. Teeple, Ph.D.

Here is an industry expanding and changing so rapidly that it is difficult to keep abreast of its progress. Every time I attempt a general review, its aspect has changed.

Processes and patents without number loom above the horizon. Most of them die without ever seeing the light of day in a commercial form, many never advancing beyond the paper and ink stage. Some start life hopefully, only to draw out a weary existence suffering from the disease known as "annual deficits." They approach so near death that when existence ceases and the scrap heap receives them we hardly notice the change.

A few, either sturdy by nature or well provided with nurses and doctors, live and grow to the mature form known as "dividend payers." These are rare, much rarer than need be if proper skill and experience were only called in at the birth of all. Like other infants their death rate is very high in the early period of existence. Fortunately, in this case, the doctor has no compunctions about letting an unpromising one die, or drowning it if need be for the good of the community.

The net results to date have been disappointing. The rewards have been few. The number of plants that have been on a real dividend paying basis for the last two years could be counted on the fingers of a one-armed man. On the other hand the crop of white hopes is large. The prospects of the industry as a whole were never better than they are to-day. A very respectable number of plants have recently started or are in process of construction. Most of these efforts show a very decided advance over those we have seen spring up in previous years.

In nearly every case, actual construction of the plant has been preceded by an investigation of the process by competent and experienced experts, and also by tests on a semi-commercial scale. Then there has been careful study of the type of raw material to be used, of the finished products and their marketability as judged by men who were thoroughly familiar with those markets, and finally an intelligent adaptation of the design and construction and location of the plant, both to the raw materials and to the finished products.

These may seem like too childish or self-evident precautions to receive special mention here, but it must be confessed that in the past, often many and sometimes all of them have been overlooked in constructing plants. Too often the process has been the whole thing. The man with a process and a long array of figures showing what wonderful products in amount and value he could get from a cord of wood, has frequently carried the investor by storm. Without waiting for the advice and experience of men who have spent years in the industry, as he would normally do in any other line, the investor plunged. There must be something fascinating about the industry, like there is about buying a mine, but nowadays even the mine buyers have an expert examination and report before buying.

A man with a process and a man with money sat at a mahogany desk. The process and the usual array of figures were there. The figures showed that from a cord of wood, kind and quality not specified, you could get wood alcohol, acetone, acetic acid, acetate of lime, turpentine, rosin, tar, pitch, oil of tar, creosote oil, sheep dip, disinfectant, wood preserver, cable coating, pine oil, liniments for man and beast and rheumatism, cough syrups, patent medicines, embalming fluids and guaiacol, and high-priced drugs of the pharmacopoeia.

Of course, it was all more or less true. The beauty of it is that you *can* get these, but the question is, do you want to? This particular investor did want to. He verified some of the prices from "Merck's index" and the "Oil, Paint and Drug Reporter" and added the long column of figures.

The fact that if you used up your raw material in making some of the products you couldn't have it left to make the others too, didn't occur to him. Further, he forgot that few of the products could be obtained from all woods, that some

would certainly be obtained from certain woods in an entirely unsalable condition, and others would cost more to make and refine in most cases than they could be sold for; still others would glut the market from one day's run of his plant, still others would probably be so different from standard articles, that their use would be restricted to special industries at much lower prices.

Overlooking all these things he followed a common practice of investors in arriving at a conclusion. He took the huge total of returns and deducted 50 per cent, then he deducted 50 per cent of the remainder. After providing this factor of safety, the total was still so large that it seemed certain a handsome profit would result no matter how it was handled. In fact, it seemed a shameful waste to use mahogany desks for office furniture when such rich returns could be obtained by distilling them. After the plant was built it was my painful duty to clear away the sad remains before it had produced a thousand gallons of anything or sold a cent's worth.

This was years ago, but I could cite many almost as bad in more recent years. There was a plant that ran intermittently almost a year without ever producing a single gallon of really marketable goods, and the men in charge did not know tar from pitch, and still no one was called in during that whole period to advise them.

There was another plant with a marketable process where the plant was designed and built complete, and only after the initial operation was started did they discover a glaring mechanical defect that made the plant as constructed, an impossibility.

There was a plant built to handle mill waste where the yields were small but a profit possible because the raw materials cost nothing, and then the whole was laid out so that every stick of wood had to be *handled twice by hand* before reaching the plant.

There was a plant constructed where raw material in the shape of lightwood was "countless as the stars," and investigation showed later that if lightwood of the kind desired was meant, the stars must have been counted on a very cloudy night.

But why continue the enumeration? It seems like a record of one case after another of useless waste. And we wonder about the high cost of living. Literally the amount unwisely expended in this industry amounts to millions. And it is not because we are lacking in competent chemical and engineering information and experience here. It is chiefly because the idea of the *process* has been overrated.

The man who can invent and think out a real idea suitable for a process has done his share. In nearly every other industry we realize that the type of mind capable of inventing is not the type most suitable for designing and constructing or managing a plant or for developing and criticizing his own process.

Why in this industry do we so magnify process and expect the inventor to be more superhuman than we do elsewhere? Why do we load him with the whole responsibility of success or failure instead of calling in the best man available to his assistance? And why do we invest in this industry on an interested man's mere word without calling in competent advice?

Within this present year I talked with an inventor anxious to interest capital in his process of recovering turpentine and rosin from wood. The conversation developed his supposition that no one else was doing this or had workable methods for doing it, and that the only thing he had to compete with was the destructive distilling type plant of thirty years ago. If the inventor, supposed to be expert in his subject, thinks this, why should we be surprised if he convinces the investor?

The process is one element of success; a good process is necessary, yes, but it is only one element, and there are many others. The character and cost of the raw material is most important and deserves an article by itself. The marketability of products has been overlooked again and again on the assumption that turpentine is turpentine and rosin is rosin. Sometimes they are, and sometimes they are not. The fact that John Jones sold his druggist a gallon of pine oil for ten dollars doesn't give you a clue as to its price and consumption in tank car lots. If you read that light oil or heavy oil is quoted at fifteen cents per gallon, that does not indicate that you can sell light oil or heavy oil from white pine at that price, or necessarily at any price.

There is really just one way to determine the marketability and price of a product and that is to sell it or products identical with it on the open market. And then, as mentioned before, the location of plant as related to raw material and market, the design, construction and management should all be done in consultation with men who have been handling this same type of installation as chemists and engineers.

A frequent mistake lies in placing the problem before an analytical chemist. He may be an exceptionally good chemist, and may give accurate reports that will be entirely misleading through no fault of his own. I have before me now such a report on a process made by a thoroughly competent analytical chemist. The report so far as I can see was correct in all respects. Unfortunately, however, from lack of specific information which he could not be supposed to possess, the report indicated success to the chemist and to the investor. A single reading of it would have convinced a man experienced in the industry that nothing but failure lay ahead, unless many things were radically changed. The report actually led to one more useless expenditure of money.

It seems probable that nearly every possible error has been made at some place or time. Most of the mistakes could have been avoided if competent experts, of whom there are a sufficient number, had been kept in touch with the work from its inception. Unfortunately in many cases the man of training and experience in this particular industry has never been called in at all. In other cases he comes to give decent interment or shorten useless suffering. Why not call him in at the beginning, in time to announce to the proud father the arrival of a bouncing baby boy?

New York City.

Wet and Dry Grading.—In testing ore for a metallurgical process, dry screening will give erroneous results if the actual practice is to be wet screening or hydraulic classification. The test should conform to the proposed practice. The following table will illustrate the point. It shows the grades obtained by wet and dry screening an ore which was tested by Morris Green, who gives his results in the September *Journal* of the Chemical, Metallurgical and Mining Society, of South Africa. The ore evidently contains some material sufficiently brittle to be broken by the impact of dry screening.

Mesh.	Dry Grading.	Wet Grading.
—30	22.15%	25.7%
—30 —60	31.55	34.9
—60 —90	9.70	9.0
—90 —120	3.20	2.9
—120 —200	9.13	7.2
—200	24.27	5.2
Slime	....	15.1
	100.00%	100.0%

Flotation of molybdenum ore by the Minerals Separation process has given the following results: The ore assayed 1.82 per cent MoS_2, from which by treatment in five successive units, a concentrate was obtained containing 92.08 per cent MoS_2, with a recovery of 76 per cent of the molybdenum in the crude ore. The ratio of concentration was 100 to 1.66.

Transvaal Gold Production.—The number of companies reporting to the Transvaal Chamber of Mines in September, 1912, was 63. The total quantity of ore milled during that period was 2,131,593 tons. There were 9970 stamps in operation, with an average duty of 8.36 tons per stamp per 24 hours. Tube-mills in commission numbered 273. The yield for the month was 747,893 fine ounces gold, which was slightly lower than for four preceding months. Fewer stamps and more tube-mills were in commission than at any time during the year.

Cyaniding Slimy Ore by Continuous Decantation

A review of the status of this important recent departure in cyanide practice, by H. C. Parmelee

THE early history of cyanidation is replete with instances of complete failure or great loss when treating ore which tended to form impermeable slime. Leachable sands were treated successfully by percolation, and in some instances it was possible to mix a portion of the slime with the sand and thus avoid a total loss of the precious metals contained therein. In other cases, however, it was temporarily more economical to discharge the slime and impound it against the time when some successful method of treatment should be devised. In this connection the revolutionary influence of agitation and vacuum filtration is a matter of common knowledge.

But great as was the effect of vacuum filtration in overcoming the obstacles in slime treatment, and important as it still is, and will be, in the cyanide industry, the more modern system of continuous decantation[1] is proving of almost equal importance in handling slime. The cyanide process is now the prevalent method of gold-ore treatment; and as the simplicity, economy and ease of operation of the continuous decantation system become better known, it is safe to predict its wider use. It has the advantage of low cost of installation and operation, and it can be combined with existing milling plants without great difficulty. In some instances it displaces filtration, other than clarifying; and where filters are used it permits the delivery of a low-grade pulp to the filter, thus minimizing the loss of dissolved gold in the filter tailing. It will be apparent, also, that the use of continuous decantation preceding filters will increase the capacity of a given plant of the latter by avoiding the time required for washing with barren solution. Eliminating this step would also decrease the cost of a filter-plant. Further, the operation of continuous decantation is simple and flexible, lending itself to a variety of conditions which may be reasonably ascertained in advance.

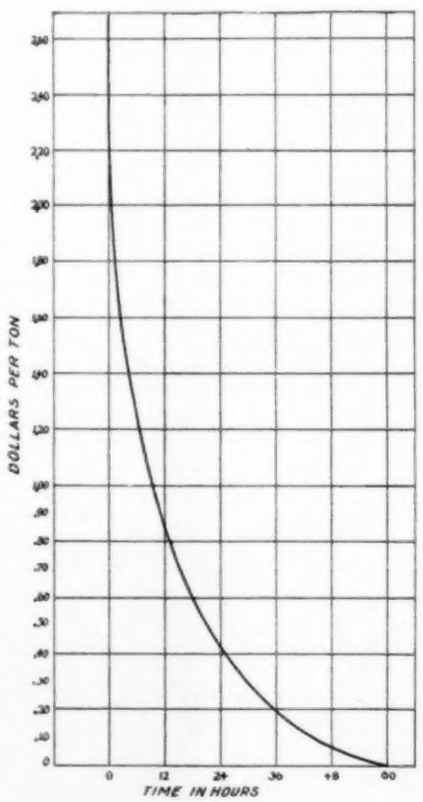


FIG. 1.—SHOWING DECREASE IN GOLD CONTENT WITH INCREASED TIME AGITATION WITH CYANIDE SOLUTION. 1 LB. KCN AND 2 LB. CAO PER TON SOLUTION. TWO PARTS SOLUTION TO ONE OF ORE. LOSS KCN 0.1 LB. PER TON ORE. LOSS CAO 1.0 LB. PER TON ORE.

Continuous Decantation at Ophir.

A case in point is the recent cyanide practice at the remodeled mill of The Ophir Gold Mines, Milling & Power Company, Ophir, San Juan district, Colorado. The company is operating a group of mines, locally known as the Suffolk property, which has a record of production extending over 3 years, and aggregating over $2,000,000 in value. Considering the situation of the property and the prevailing metallurgical methods it was natural that during the early years of its history, only high-grade ore was mined and milled. Recovery was effected almost wholly by amalgamation, with some concentration. The value of the ore treated ranged from $15 to $100, and the recovery probably did not exceed 60 per cent. Under the present system of cyaniding, without amalgamation or concentration, ore averaging $3 gross value per ton can be mined and milled at a profit, with a recovery of over 90 per cent.

Nature of the Ore.

The Suffolk ore consists of quartz, decomposed porphyry and andesite, and contains gold to the value of from $8 to $12 per ton. Silver is found only in negligible quantities, and practically no other metals are present. Analyses show over 90 per cent insoluble. The ore is soft, a great deal of it being in the form of clean clay resulting from the decomposition of the porphyry. This condition readily explains the failure of former attempts at cyaniding by leaching. It also gives rise to much colloidal slime in the present system of treatment, but no difficulty is experienced in handling it.

Preliminary Experiments.

Preliminary experiments revealed certain ideal qualities for cyanidation not found in all ores. There are no reducing agents present and the ore is only slightly acid. Chemical consumption of cyanide is only 0.1 lb. per ton, and of lime 1 lb. per ton. Being soft, the ore is readily ground to slime. This is an important characteristic because the gold is very finely divided, and, after crushing, is found for the most part in the fine slime. Despite the fact that the ore contains a great deal of collodial matter, and therefore does not settle readily, no difficulty has been experienced in handling it by the present method of continuous decantation.

An interesting feature disclosed in the tests was the fact that the quantity of readily soluble gold varied directly with the gross value of the ore, while the quantity of gold requiring time and agitation for its solution was almost constant regardless of the initial value of the ore. Thus it was found that on all grades of ore the gold went into solution almost immediately to a point where the residues had a uniform value of $2.40 per ton.

These residues yielded their gold on further agitation as is indicated in the time-solution curve shown in Fig. 1. From this it will be seen that solution goes on quite rapidly, giving residues containing twenty cents gold per ton after 36 hours agitation.

This is the standard now maintained in mill operation, although as a matter of fact "trace" tailings frequently are obtained.

[1] Articles relating to continuous decantation have appeared in this journal for July, 1911, pp. 365 and 373; Sept., 1911, pp. 436 and 439; Nov., 1911, p. 605; Jan., 1912, p. 27.

Crushing in Cyanide Solution.

The present milling system, based on many tests and calculations, is shown concisely in the flow-sheet, Fig. 2. In this connection it will be interesting to note that the results obtained in practice checked closely those indicated by the calculations. The flow-sheet shows the strength, value and tonnage of solution and pulp at different points in the process, so that it will be readily understood without much description. The figures are based on an assumed ore-value of $5 per ton.

The milling process begins by crushing the ore in cyanide

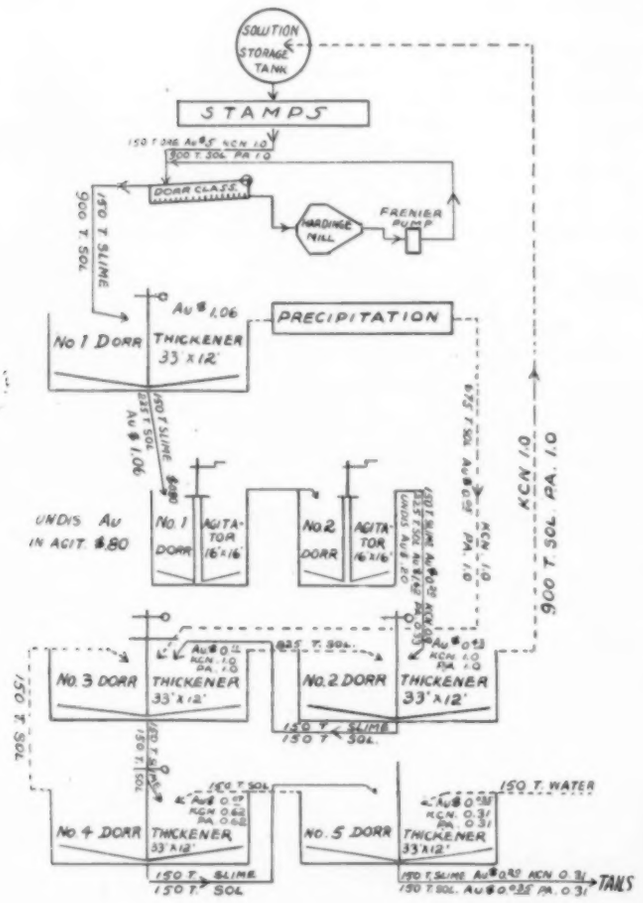


FIG. 2.—FLOW SHEET OF OPHIR GOLD M. M. & P. CO.

solution with twenty 850-lb. stamps. The height of drop is from 6 to 7 in. at the rate of 104 drops per minute. With ¼-in. screens on the mortars the twenty stamps have a capacity of 150 tons in 24 hours, and 30 per cent of the discharge will pass a 200-mesh screen.

Considering the nature of the ore, the stamping is not so much a problem of crushing as of disintegrating and washing out the clay.

The stamp product is separated into sand and slime in a Dorr classifier, the sand being reground in an 8-ft. Hardinge conical mill. The latter carries a 4-ton charge of pebbles and runs at 31 r.p.m. Its discharge flows to an Abbe-Frenier pump which returns the pulp to the classifier. The classified slime is elevated by centrifugal pump to the first Dorr thickener, 33 ft. diameter and 12 ft. deep, running at the rate of one revolution in 12 minutes. Solution of most of the gold occurs so rapidly in the stamp-mortar and tube-mill circuit that the overflow of this thickener is clarified and precipitated by zinc dust. The consumption of the zinc amounts to 0.15 lb. per ton of solution.

The rich solution is measured before precipitation, by means of an all-iron Worthington direct-displacement water-meter. An automatic sample is taken both before and after precipitation. The difference between the assay-value of these samples, multiplied by the tonnage registered on the meter, gives the amount of gold precipitated during a given period.

Agitation.

The thickened slime, containing 1½ parts solution to 1 of solids, flows to the agitators which are shown in Fig. 3 as they appeared before being enclosed in an addition to the old mill building. The agitators are of a new type, combining air and mechanical agitation, patented by Mr. J. V. N. Dorr. The mechanism is applicable to flat-bottom tanks of ordinary proportions; those at Ophir are of wood, 16 ft. high and 16 ft. diameter. The driving gear is supported on a frame-work at the top of the tank as shown. The central air-lift pipe is connected with the vertical driving shaft and revolves with it, being suspended in the tank. The open bottom of the central pipe reaches within 8 in. of the bottom of the tank and is directly above the inlet-valve for compressed air. Attached to the air-lift pipe near its lower end are the agitator arms to which are riveted angle-irons so placed as to draw pulp from the periphery to the center of the tank during the revolution of the mechanism. The arms are adapted to be lifted out of the pulp in case operation is discontinued for any length of time. The pulp discharged from the air-lift is directed into inclined radial launders attached to the top of the central pipe and revolving with it. The bottoms of the launders are perforated to distribute the discharge over the surface of the pulp.

In operation, therefore, there is a combination of air and mechanical agitation. The arms, which in this case revolve only once in 54 seconds, continually draw thickened slime from all parts of the tank and deliver it to the air-lift for circulation and agitation. This agitator is giving entire satisfaction. It avoids the inconvenience in mill construction due to the great height of Pachuca tanks, and it overcomes the difficulties arising from accumulation of sand, which frequently occurs in cone-bottom agitators.

It is recognized that in many types of agitators the intensity of agitation is determined more by the mechanical necessity of keeping the pulp in suspension rather than by the chemical requirements of the ore under treatment. This frequently results in a waste of power; and where air-agitation alone is used, the excess of air may readily be a disadvantage. This agitator

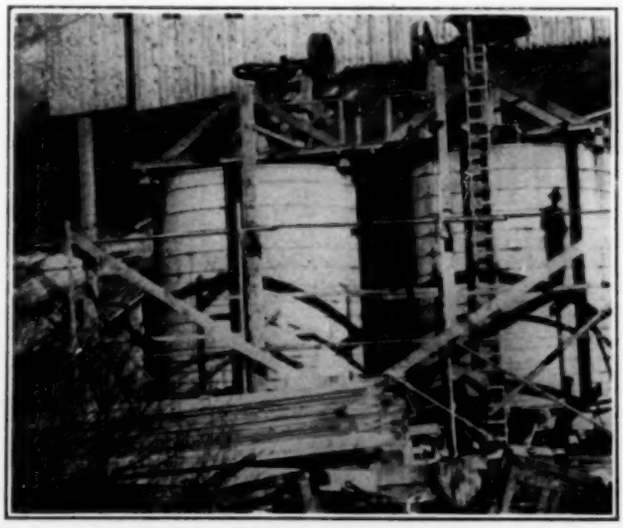


FIG. 3.—AGITATORS, OPHIR MILL.

maintains the pulp in suspension under every condition, and allows the intensity of agitation to be regulated to suit the needs of the ore.

Continuous Decantation.

The agitated pulp is subjected to a system of continuous decantation and counter-current dilution as outlined in the flow-sheet. The final tailing is discharged from the last thickener

without filtration. The loss in dissolved gold at this point is but three cents per ton, which compares favorably with similar loss from filters, the latter ranging from four cents up as high as twenty cents or more per ton. The discharged pulp contains from 48 per cent to 54 per cent solids. In applying this system, a vital thing to be observed is the point at which barren solution is added; and this is governed by the relative value of the pulp in cyanide and dissolved gold, and the proportion of each that may be most economically discharged in the final tailing.

It will be noticed here that in the present case the barren

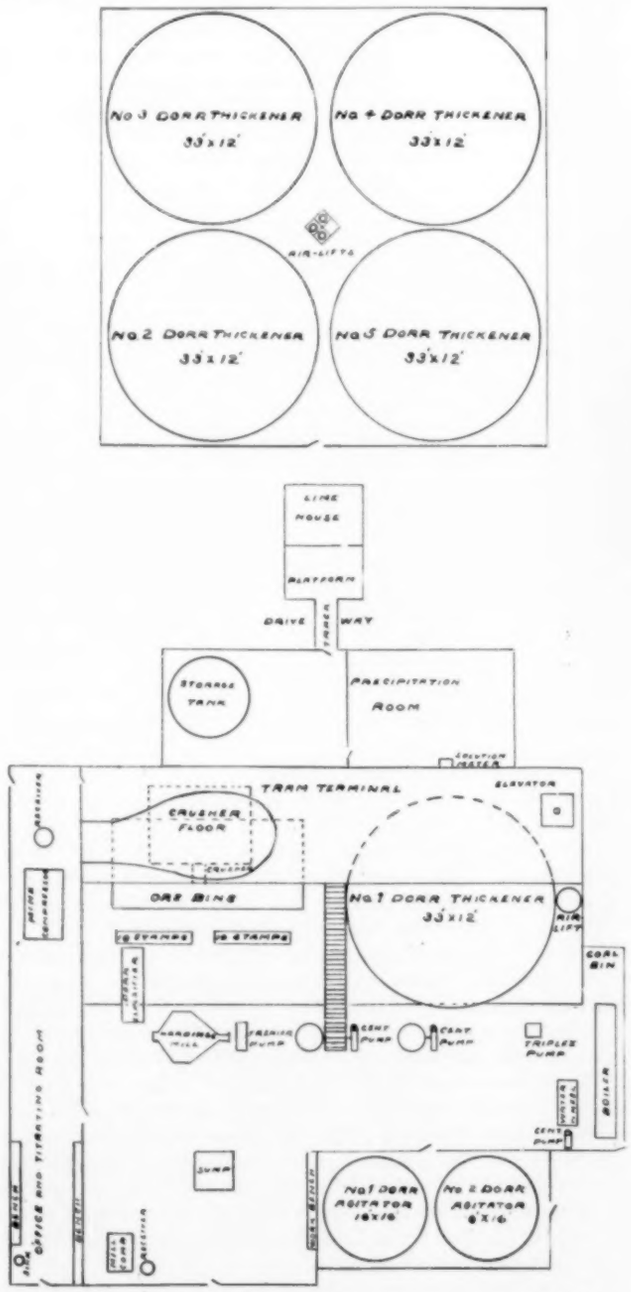


FIG. 4.—PLAN OF MILL, OPHIR GOLD M., M. & P. COMPANY.

solution is added in the third of the five thickeners. This is based on experiments and calculations designed to give the lowest combined loss of cyanide and gold, and is not necessarily the exact scheme which would be followed with other ores and solutions.

By reference to the flow-sheet it will be seen that the flow of solution through the entire mill system is in a closed circuit, except for that portion of solution discharged as moisture in the final tailing. This is compensated by the addition of hot water from the heating system, so that the solution is kept at an average temperature of 85 deg. F. The quantity of hot water thus introduced is governed by a float in the mill-solution storage tank, which operates a throttle valve on the hot water line.

The float is placed in this tank because it is the only one in the entire system in which the level of solution varies. It is also the only tank in the system besides the treatment tanks. Sump-tanks are not needed.

Air-Lifts for Transfer of Pulp.

An important feature at Ophir is the convenient arrangement and control of the air-lifts used for transferring pulp from one thickener to another. These lifts are similar to those used at Real del Monte, Pachuca, Mexico. The four thickeners are symmetrically arranged as shown in Figs. 4 and 5, and in the central space are grouped the air-lifts and boxes which receive the various pulps and solutions. This arrangement greatly facilitates inspection of the entire system of continuous decan-

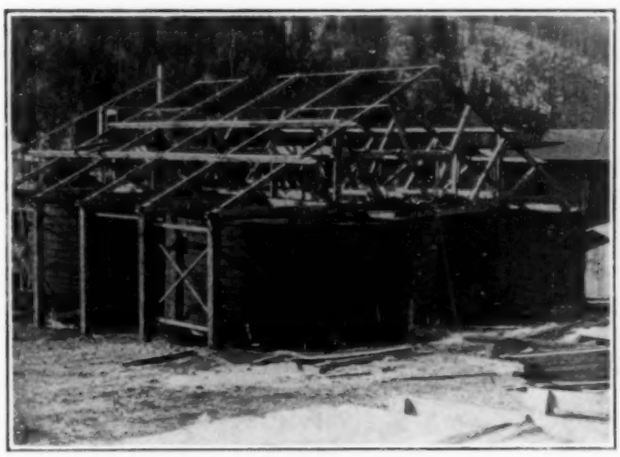


FIG. 5.—SHOWING ARRANGEMENT OF THICKENERS IN CONTINUOUS DECANTATION DEPARTMENT. OLD MILL IN RIGHT BACKGROUND.

tation. The thick underflow discharged through a nozzle, and the overflow to be mixed with it, flow into a sump-box, and the mixture is elevated to the proper tank by an air-lift.

The construction of the air-lifts, of which there are three, is shown in the drawing, Fig. 6. The thickened pulp and diluting solution which are to be transferred to any one of the thickeners are received in one compartment of a box which is 2½ ft. square and 3 ft. deep. Attached to the bottom of each compartment, and extending downward into a concrete-lined well, is a 9-in. pipe, 23 ft. long, capped at the bottom. This gives a total submergence of 25 ft. below the normal level of slime maintained in the box. Inside the 9-in. pipe, and extending downward within 4 in. of its bottom cap, is a 5-in. pipe which rises also 13 ft. above the surface of the slime in the box and discharges the elevated pulp to the feed box of the desired thickener. The inner pipe is supported on legs resting on the cap of the outer pipe. A 1-in. compressed-air pipe is introduced into the top of the 5-in. pipe and extends downward within 10 in. of the bottom of the 5-in. pipe.

In each compartment of the box referred to is a float rigidly connected by an iron rod with a throttle valve on the air line. As the pump accumulates in any compartment, the float rises, opens the valve and operates the air-lift. When the level of slime in that compartment has been lowered, the float automatically closes the air valve and the elevation of pulp is temporarily discontinued. These pumps have proved effective in pulp transference and are economical in air consumption. They require little or no attention, and the only cost is for power.

Air is supplied at 30 lb. pressure, and under this condition the consumption of air is 30 cu. ft. per minute for the three lifts. In this connection it may be stated that throttle valves proved superior to butterfly valves, as the latter did not close as

tightly nor as quickly as the former, thus allowing an escape of air following each discharge of pulp.

In order to prevent the violent discharge of the air-lifts from agitating the settling pulp in the thickeners, a wooden float is placed in each feed-box to break the force of the incoming stream. The central feed-box is 3 ft. square and 5 ft. deep, dipping about 3½ ft. below the surface of the pulp. The wooden float clears the sides of the box by a few inches and has a centrally-bored hole through which the driving shaft of the thickener passes.

Another system for transferring pulp may be noted here.

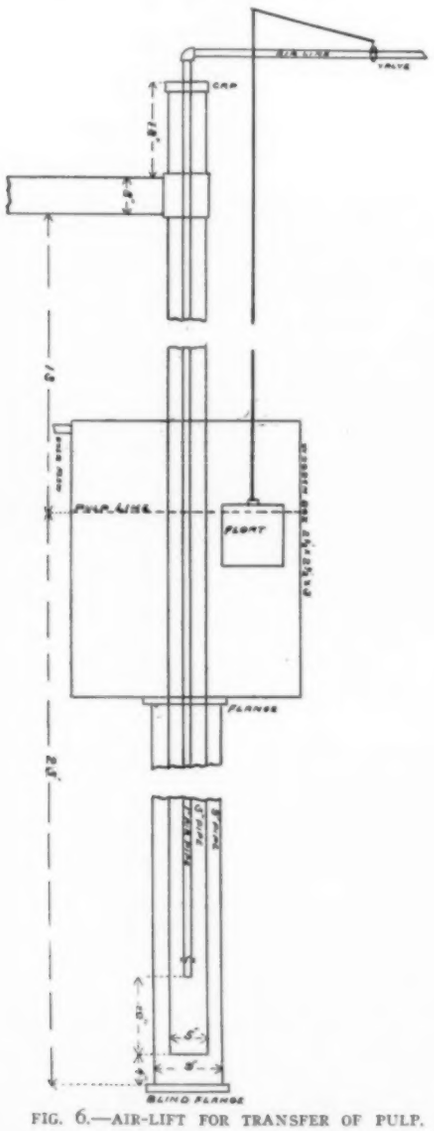


FIG. 6.—AIR-LIFT FOR TRANSFER OF PULP.

This consists in withdrawing the thick pulp by means of a diaphragm or other displacement pump set near the top of the tank. The pump discharge is then mixed with the proper overflow which flows by gravity from an adjoining tank.

This method gives closer regulation of the thickened discharge, as the withdrawal of the same volume in unit time means the delivery of more solid if the pulp becomes thick, and less as it becomes thin. The disadvantage of this system is the wear of diaphragms, which is partly compensated by the smaller power required.

Power, Labor and Sampling.

The property is favorably situated for the use of inexpensive water power, of which from 800 to 1000 hp. can be developed. At present two Pelton wheels are generating all the power required by the mill and the mine compressor. One 6-ft. wheel with two 3¾-in. nozzles is operating under a head of 100 ft., and one 3-ft. wheel with a 2-in. nozzle is running under a heat of 375 ft. The mill is consuming about 110 hp. when treating 150 tons per day.

The labor normally required per shift in the mill is two men, with a repairman on the day shift, in addition to which there is a mill superintendent.

An automatic sampling system has been installed, controlled by a master-clock. The samplers are placed to receive the battery discharge, agitator discharge and final tailing from the last thickener. Samples are taken simultaneously for one second of time at half-hour intervals.

The work at this mill is worthy of note on account of the simple system of ore-treatment, which gives the best results at a low operating cost. The unit cost of installation, which in the last analysis must be distributed as an additional operating cost over the total tonnage to be treated, is considerably lower than would be the case for the usual filtration system.

We are indebted to Mr. George B. Pickett, general manager for the company, for permission to publish these data; and to Mr. Justin H. Haynes, general superintendent, and Mr. F. L. Veatch, mill superintendent, for supplying the details of the process as they have applied it to local conditions.

The Determination of Phosphorus in Vanadium Steels.

By E. W. Hagmaier.

The determination of phosphorus in the presence of vanadium has been a bugbear ever since vanadium steels have come into extensive use. The methods have either been long and tedious or not very reliable. The following method besides being short has proven accurate under all conditions in which it has been used:

The sample of steel is dissolved in aqua regia, taken to dryness and baked. When all the acid is driven off it is then taken up in strong hydrochloric acid; when complete solution is obtained the silica is filtered. The filtrate is then reduced with sulphurous acid. When entirely reduced 5 cubic centimeters of acetic acid 90 per cent and 10 cubic centimeters of cerium chloride saturated solution are added. Ammonium hydrate (about 1 part concentrated ammonia to 3 of water) is added drop by drop with constant stirring, until turbidity is shown. The solution is then heated to a boil, allowed to settle, and filtered. The cerium phosphate will filter rapidly, especially through a black ribbon paper. The precipitate is washed five or six times with hot water and then dissolved off the paper with hot (1-1) nitric acid, and the phosphorus precipitated as in other cases with ammonium molybdate.

Precautions:—It is better to filter off the silica before precipitating the cerium phosphate, for the presence of the silicon causes the cerium phosphate to filter slowly.

The point where most caution is required in the whole method is in adding the ammonium hydrate. This must be added very slowly, for if once too large an amount is added it seems impossible to obtain proper conditions by coming back again with hydrochloric acid. If by accident too much ammonium hydrate is added, the best plan is to filter the precipitate, redissolve it in hydrchloric acid, pass in sulphur dioxide, and reprecipitate the cerium phosphate.

This method has been tried with vanadium from 0.166 up to 5 per cent, and it has been found that in all cases above 0.5 to 1 per cent one reprecipitation of the cerium phosphate should be made, and with 1 per cent to 5 per cent vanadium two reprecipitations.

The following experiments were carried out by the above method, and in no case where the necessary precautions were taken did the ammonium phosphomolybdate precipitate show the orange color characteristic of vanadium contamination. The ammonium phosphomolybdate precipitation was also taken, redissolved and tested for vanadium, and no trace of vanadium was found.

In all of the following experiments the molybdate precipitate was filtered on a weighted paper and the phosphorus calculated using .0163 as the factor.

One gram of a steel having 0.60 phosphorus and 0.16 vanadium added. The following results were obtained: No. 1, 0.633 per cent P; No. 2, 0.596 per cent P; No. 3, 0.595 per cent P; No. 4, 0.614 per cent P.

One gram of steel having 0.60 per cent phosphorus and 0.767 per cent. vanadium. The following results were obtained: No. 1, 0.585 per cent P; No. 2, 0.570 per cent P; No. 3, 0.625, per cent P; No. 4, 0.640 per cent P; No. 5, 0.572 per cent P; No. 6, 0.619 per cent P.

Ten grams of steel having 0.025 per cent phosphorus and 0.166 per cent vanadium. The following results were obtained: No. 1, 0.023 per cent P; No. 2, 0.018 per cent P; No. 3, 0.025 per cent P.

One gram of cast iron having 0.532 per cent phosphorus and 0.956 per cent vanadium added. The following results were obtained: No. 1, 0.539 per cent P; No. 2, 0.526 per cent P.

Pittsburgh, Pa.

Notes on Metallurgy in British Columbia in 1912.

By E. Jacobs.

The quantity of ore and concentrate smelted at the Consolidated Company's works at Trail was between 300,000 and 320,000 tons, which was less than in the fiscal year to June 30, 1910 (487,000 tons), and the next following fiscal year (389,000 tons). The decrease was caused by loss of the Snowshoe mine ore, of which there was 268,000 tons, received in the two fiscal years quoted. Improvements included an addition to flue chamber, to secure better results in settling of flue dust from copper ores; rebuilding of matte-handling plant, the method of treating low-grade matte having been changed; alterations to lead-sampling plant, made necessary by increase in quantity of coarse lead ore received; more electrolytic tanks in lead refinery, to provide for larger output of refined lead; and numerous changes, chiefly to facilitate handling materials. Experiments in reduction of zinc-lead ores were carried out, but no provision was made for production of spelter on a commercial scale.

Copper Smelting.

Last February, at the Trail smeltery, experiments were commenced to smelt the raw matte pyritically, to take the place of the former more expensive method of roasting and sintering, and if possible without any considerable alteration to the furnaces already in use. The smallest furnace, dimensions 42 by 240 in., was blown in on a charge consisting of matte 2,500 lb., silicious ore 1,500 lb., lime rock 12 per cent, and coke 3 per cent. This furnace was blown out after having been in blast 12 hours, as it ran so fast the matte-tappers could not keep the matte down in the settlers. It was decided to cut the furnace in two, which was accordingly done, making the area at the tuyeres 42 by 120 in. The smaller furnace was then blown in on a similar charge, the coke being shoveled and the remainder of the charge dumped in from the side and distributed along the furnace by the locomotive in the same manner as for the ore-furnaces. The matte on the charge was coarse, about 6 in., while the silicious ore available was very fine, 50 per cent passing through a ¼-in. screen.

The furnace was run on this charge for two days but never got properly heated, owing to the looseness and shallow depth of the charge. The next run was tried with a heavier charge and with matte crushed to 2 in., and, while this acted better, the sides of the furnace rapidly crusted, owing to the fine nature of the silicious ore. After several attempts with long-nosed cars and distributing plates, to try to get the charge into the center of the furnace, the ends were taken out of the hood and the furnace fed along the center with bottom-dump cars. This method proved successful. Two charge cars are used, and the charge of 4,200 lb. matte, 2,000 lb. silicious ore, 13.5 per cent lime rock, and 4 per cent coke is divided equally between the two.

The coke is fed by shoveling and the remainder of the charge is weighed in the cars—matte first, then ore, and lime rock on top. If the furnace shows signs of crusting the matte is weighed on top of the ore for a time, thereby throwing more matte along the sides, which invariably has the desired effect of cutting out the crust.

The matte is concentrated twice in this furnace, the first concentration running from 15 to 20 per cent copper, equivalent to a reduction of from 2.5 to 3 into 1. This matte is returned to the furnace and smelted with sufficient low-grade matte to keep the grade about 40 per cent copper for the second concentration. All the matte is tapped into Kilker's 1½-ton matte-tapping cars (five of which are used), cooled, and hauled by electric trolley locomotive to the crushing plant.

The pans of the matte-cars dump directly into a 10 by 20-in. jaw-crusher and thence to a pan conveyor which discharges into three iron bins, whence the matte is drawn into V-shaped cars and hauled to the charge bins or shipped to Tacoma, Washington (for converting), according to grade.

Slag from the ore-furnaces assays, approximately: FeO, 14.5 to 16; SiO_2, 40 to 47; CaO, 18 to 22; MgO, 1.5 to 3; Al_2O_3, 14 to 16.5 per cent; S, trace. Slag from the pyritic furnace runs about FeO, 45 to 50; SiO_2, 35; CaO, 12 per cent.

This information was kindly supplied to the writer by James Buchanan, superintendent of the Consolidated Mining and Smelting Company of Canada's smeltery at Trail.

The chief change at the Granby Company's smeltery was in the substitution of water-granulation of slag for dumping it molten. By a system of conveying belts, operated by electric motors (already described in this journal), the dewatered slag is conveyed up a long incline to a height of 120 ft. and then dumped, this arrangement providing dump room for all slag that will be made for six or seven years. The quantity of ore from Granby mines treated in 1912 was more than 1,200,000 tons. One notable feature of the year's work was that the full battery of eight blast furnaces was operated all the year, one run having been for 156 consecutive days without interruption. The company is purchasing materials and plant, and other equipment for a 2,000-ton smeltery, hydroelectric power station, shipping dock, etc., at Granby Bay, Observatory Inlet, where its new mine is being developed with promise of large productiveness.

The British Columbia Copper Company operated its smeltery throughout the year. Ore receipts totalled between 650,000 and 700,000 tons. High efficiency was secured, monthly totals of ore smelted having ranged as high as 65,000 tons, with three furnaces in blast. The greater part of the ore smelted came from the Mother Lode and Rawhide mines. There is in the company's Lone Star mine a large amount of ore available, but owing to its high silica content, it has been deemed inadvisable to endeavor to smelt it with that from the company's other mines. For some time past concentration tests have been made with the object of determining how best to eliminate the excess of silica. The ore presents unusual obstacles to concentration, but notwithstanding this the problem is now in a fair way toward being successfully solved. Favorable results will have an important bearing upon the question of ore supply for the company's smeltery. In value the general tenor of the ore is higher than that of the average of Boundary district ores.

Most of the copper concentrate and the ore shipped crude from Coast district mines was treated at the smelting works at Tacoma, Wash. This includes the comparatively large output of the Britannia mine.

Gold Milling.

While a large proportion, nearly three-fourths, of the lode gold produced in the province is obtained by smelting ores containing copper, the remaining one-fourth is recovered by stamp-milling and auxiliary cyaniding. The largest stamp-mill operated is that of the Hedley Gold Mining Company, at Hedley, Similkameen, where approximately 70,000 tons of ore was crushed in 1912, as compared with 58,000 tons in 1911. No gold is saved on plates, but fully five-sixths is contained

in concentrates from vanners and tables, while the remainder is recovered in cyanide bullion. Approximate value of gold recovered in 1912 was $763,000, or an average of rather less than $11 a ton; in 1911 it was $680,000, with an average recovery of $11.75 a ton. Estimated net earnings for 1912 were $407,500, as against $308,800 in 1911.

There were three 20-stamp mills operated in Nelson mining division in 1912, but information is not available concerning two. The third is that of the Mother Lode Sheep Creek Mining Company. During four months, July-October, 7,755 tons of ore was crushed. The extraction was nearly 98 per cent; the value of the product was $102,869—average $13.265 a ton Operating expenses were $7.245 a ton. November and December figures were not received. The mill is modern in its equipment. Higher net returns are expected from next year's operations.

A new installation was that of a 10-stamp mill at the Inland Empire mine, near Paulson, in the western part of Trail Creek mining division. Only a light saving is made on the plates. The daily output of concentrate is 30 to 40 tons, which is shipped to Trail for smelting.

Lead and Zinc Concentration.

The Standard Silver-Lead Mining Company shipped 4,400 tons of sorted ore to the smeltery, and concentrated 32,600 tons of mill ore. Products were 5,400 tons of silver-lead and 3,300 tons of silver-zinc concentrates. Metal contents of all shipments were: Silver, 832,000 oz.; lead, 12,440,000 lb.; zinc, 2,706,000 lb. Silver-lead concentrate was shipped to Trail, B. C., and silver-zinc to Bartlesville, Okla. The mill has been run only one-shift per diem, but it is to be operated double shift hereafter.

The Van-Roi Mining Company, also operating near Silverton, Slocan Lake, concentrated 54,000 tons of ore. Average assay of feed showed: Silver, 15.02 oz. per ton; lead, 3.66 per cent, and zinc, 6.26 per cent. Concentrates produced, and metal contents were as follows:

	Metal Contents.		
	Silver, oz.	Lead, per cent.	Zinc, per cent.
Lead concentrate, 2,392.5 tons.....	179.75	60.2	11.1
Zinc concentrate, 2,570.5 tons.....	60.8	3.7	45.1
Tailing	4.6	0.9	4.0

An auxiliary aerial two-bucket tramway was constructed from mine to mill.

At the New Canadian Metal Company's mill, at Riondel, Kootenay Lake, operated in conjunction with the company's Bluebell mine, milling was resumed on July 4, after a long suspension of operations. During six months 33,000 tons of ore was milled; production was 49,600 oz. of silver and 4,172,000 lb. of lead. Capacity of mill is being increased from 225 tons to 300 tons per diem.

Several other concentrating mills were operated, but on a smaller scale than those above-mentioned.

General.

Gold and gold-copper ores are either milled or smelted in the province, with the exception of the latter ores in the Coast district, much of which is shipped to the smeltery at Tacoma, Washington. Silver-lead and lead ores are either shipped crude to Trail, or concentrated and the product sent there, the Consolidated Company's lead-smelting and refining works being the only one reducing lead ores in British Columbia. Zinc-lead ores are concentrated and the zinc product, as well as crude zinc ore, is shipped to the United States, chiefly to Bartlesville, Okla., for reduction. The works of Beer, Sondheimer & Co., at that place, receive the zinc concentrate output of the Standard, Van-Roi, Hewitt-Lorna Doone, and Monarch mines. The Lucky Jim and Noble Five mines ship crude zinc ore, the latter in much less quantity at present than the former. Noble Five zinc ore contains up to 56 per cent zinc.

Approximately 60,000 oz. of gold was received in 1912 for melting at the Dominion of Canada assay office, Vancouver, B. C. Of this total, about 70,000 oz. came from British Columbia mines, 2,500 oz. from Yukon Territory (Canada), and 7,500 oz. from Alaska. Much of this gold was from placer mines.

The greater part of the 250,000 to 260,000 oz. of lode- also copper-bearing.

Regarding the bounty paid by the Federal Government on lead mined and smelted in the province, when the London price of lead is £14 or under, the amount of bounty payable is at the rate of 75 cents per 100 lb., but by the sliding scale the amount payable diminishes as the price rises, until, at £18 per ton it is entirely extinguished. During 1912 the lead content of ore and concentrate delivered to the smeltery at Trail totalled, approximately, 22,000 tons. Bounty was payable until June, in which month the price rose to £18 and higher, and it remained higher than £18 throughout the remaining months of the year. Consequently the total amount of bounty earned in 1912 was only about $65,000. The original appropriation made in 1903 was $2,500,000; of this sum there remains unearned about $700,000. The bounty payable under the present act "shall cease and determine on June 30, 1913," but those chiefly concerned are petitioning the Federal Government to continue to aid the local lead-mining industry in a similar or some other suitable form.

It may be of interest to note that the Dominion Director of Mines has had one of the officials of the Mines Branch of the Canadian Department of Mines engaged in an investigation of the Canadian market for various mineral products in a crude or partly prepared condition. The official referred to spent part of 1912 in British Columbia, and afterward continued his investigations in other parts of Canada. The ultimate object of this investigation is the further encouragement of the use of Canadian minerals as material in Canadian manufactures. It also includes pointing out to producers the requirements of the domestic market, and indicating the form in which minerals should be prepared for use in the various industries in which they are to be employed. The results of this work will thus set forth what minerals are at present in use in the manufacturing industries of Canada, their sources, the uses to which they are put, the degree of purity required for the various processes in which they are used, and the physical condition in which they are purchased.

In conclusion, it may be added that a preliminary estimate of the mineral production of British Columbia in 1912 indicates that it has been, in both quantity and value of mineral produced, a record year for the province. The estimated total value of the mineral production is $31,500,000, of which nearly $17,000,000 is for metallic minerals, and of this less than half a million is for placer-gold. The highest previous annual production was that for 1910—$26,377,000. Estimates for 1912 show the following quantities of lode metals recovered: Gold, 250,000 oz.; silver, 2,700,000 oz.; lead, 35,000,000 lb.; copper, 50,000,000 lb.; zinc, 6,000,000 lb. The gross output of coal was 3,040,000 long tons, part of which was made into 263,000 tons of coke. Miscellaneous non-metallic minerals, other than coal, are estimated at $3,800,000. The outlook is favorable for further increase.

The **Efficiency Society** will hold its annual meeting at the headquarters of the Society, 29 West 39th Street, New York City, on Monday and Tuesday, January 27 and 28. There will be symposia and discussions on management; on democracy in industry and securing the consent of the governed; on efficiency in the government organization, national, state and municipal or a readjustment of the governmental departments; on industrial relations; on the relations between employer, employee and the community; on industrial hygiene and safeguards against occupational disease and accident, and on safety. Mr. James G. Cannon, president of the Fourth National Bank, is the first president of the society. Among the other directors are Messrs. Bion J. Arnold, W. W. Freeman, William Jay Schieffelin and Schuyler S. Wheeler.

Protection of Intellectual Property in Relation to Chemical Industry.*

By Dr. Leo H. Baekeland.

Intellectual Property Rights.

The mass of unthinking people, as well as those whose views are predominantly guided by precedent, have little or no conception of the natural rights of intellectual property. It is difficult to teach such people that adequate protection of intellectual property is abundantly more beneficial to the community at large than to the temporary individual possessors of these rights.

Yet these same people consider as sacred and inviolable, any other property rights as soon as the latter relate to chattels or real estate, whether such rights were obtained by purchase, by inheritance, by gift, by privilege, by labor, or by any other way.

Furthermore, the laws of all nations are very strict in protecting such property rights, but do not concern themselves, beyond certain limits, whether the possessor of the property is morally entitled to it or not. Neither do our laws concern themselves whether the owner uses his property for good or for wrong, for the benefit of the community at large, or for the gratification of his own selfish purposes. From the standpoint of the law (with very few exceptions, such as for instance, Board of Health or police ordinances, or cases of so-called eminent domain), it matters little whether the private ownership of some property is a burden to the community or whether it is an impediment to the happiness or the free development of its citizens.

Neither is there any dispute as to the time the ownership of such property should last. Except for restrictions put on ownership by taxes, property rights are practically perpetual, and can only be transferred by accepted methods, as for instance, sale, barter, inheritance, or donation.

In some rare instances, there may be expropriation for public purposes (or eminent domain), but even then, some suitable compensation is usually made.

All this is readily accepted as an axiom, as an underlying article of faith by all laws relating to property. Only the socialist dares dispute these rights, while even the single taxer admits them to such a decided extent that he desires to abolish taxes on all property created by labor or enterprise, so as to shift the burden of all taxation on unearned land values.

When, however, it comes to recognize the claims of ownership to intellectual property, the result of the truly creative effort of the citizen, we butt right away against some stubborn conceptions, which have petrified into the code of our long established laws.

If Tom steals Dick's two-dollar scarf pin, Dick will have little trouble in putting Tom in jail, even if Dick himself has obtained his pin by questionable methods. But when it comes to protect even for the short period of seventeen years, the most logical, the most legitimate personal property, intellectual property as embodied in patent rights, with all that it involves, with enterprises depending thereon, based often on the work of a life-time, then our law courts are woefully deficient, on account of the uncertainties, delays and enormous expenses connected with the adjudication of patent rights. All this works overwhelmingly in favor of the litigant with the well filled purse, the large corporation.

Fundamental American Patent Law.

Yet, no country in the world has expressed in a fairer and broader spirit, the rights of intellectual property, than the United States, in Article I, Section 8, of the Constitution: "Congress shall have power to promote the progress of science and the useful arts by securing for limited times to authors and inventors, the *exclusive* right to their respective writings and discoveries."

This proclamation lifted the right of a patentee at once, far beyond the mere privilege conferred by most other countries, which grant patents not only to the real inventors or originators, but also to those who are first to introduce unpublished inventions into their respective countries. With some legitimate pride, we can say that in this respect at least, American patent law stands head and shoulders above the laws of Germany, France and England.

The principles of the right of intellectual property so clearly defined in our Constitution, were repeated in the preamble of the French Law of Jan. 8, 1791, which declares:

"The National Assembly, considering that every new idea, whose manifestation or development may become useful to society, belongs to him who conceived it, and that not to regard an industrial invention as the property of its author would be to attack the essential rights of man; considering at the same time how much the lack of a positive and authentic declaration of this truth may have contributed till now to discourage French industry by occasioning the emigration of numerous distinguished artists and by causing to pass out of the country a great number of new inventions from which the Empire ought to have drawn the first advantages; considering finally that all the principles of justice, of public order, and of national interest imperatively command that it determine for the future the opinion of French citizens with regard to this class of property by a law which consecrates and protects it . . . etc."

The wisdom of these provisions has abundantly been proved by subsequent events. Only a man stubbornly blind to evident facts, will deny that just those countries which have the most liberal laws for patent protection, are also those which have taken the lead in the industrial and scientific development of the world. No man was more imbued of the benefits of the patent system than Abraham Lincoln, when in 1860, in his speech at Springfield, Ill., he said:

"In the world's history, certain inventions and discoveries occurred of peculiar value, on account of their great efficiency in facilitating all other inventions and discoveries. Of these were the art of writing and of printing, the discovery of America, and the introduction of patent laws. . . . The patent system . . . added the fuel of interest to the fire of genius, in the discovery and production of new and useful things."

Inadequacy of American Patent System.

Up to about thirty years ago, our patent system covered tolerably well the purpose for which it was intended. It stimulated individual inventions and promoted numerous private enterprises. Since then, with the extraordinary growth of our nation, with the tremendous increase of agglomerations of capital for industrial enterprises, and more specially with the astonishing increase in the ramifications of applied science, our patent system has become totally inadequate to the needs of the country; it suits our new conditions in about the same way as baby clothes fit an overgrown boy.

Our patent system, although based on an excellent fundamental law, has now degenerated into a set of exceedingly complicated technicalities of law practice, a system of legal acrobatics, whereby any contestation before the courts can be turned into "perpetual motion" to the advantage of wealthy litigants, and whereby the individual patentees of slender means and the small industrial concerns, find themselves under smothering disadvantages when opposing rich antagonists. In this way, our patent system, instead of accomplishing its intended purposes of stimulating individuality, simply reinforces the rich and big industrial enterprises, and discourages the individual inventor unprovided with a liberal bank account.

New Rules of Supreme Court.

It is true that on November 4, 1912, the Supreme Court of the United States, has promulgated revised Rules of Practice for the Courts of Equity, which intend to simplify our methods of litigation. Unfortunately, this is only a half-way measure, leaving still abundant opportunity for the tactics of delay,

*Presidential address delivered before the American Institute of Chemical Engineers at the Detroit meeting, December, 1912.

chicane, and expense which have too much disgraced American patent litigation.

These new rules might gain in efficiency, if they were supplemented by the creation of a final court of patent appeals. They might be made incomparably more efficient if they could be strengthened by a system whereby the adjudication of the validity of patents does no longer devolve upon judges who do not possess the technical or scientific preparation required nowadays for discerning the merits of complicated patent questions. Some of the far-reaching details of scientific technology absolutely baffle the comprehension of those who have no preliminary technical or scientific training. Certain problems of chemistry and physics involved in many patent suits, can no longer be understood by an intelligent judge, if he has not had long and systematic preliminary training in that branch of knowledge. I do not deny that an intelligent judge can be coached and instructed by long, tedious, time-robbing methods, even in intricate scientific problems; but his education has to be made over again for each special case. After you have made a chemist of him for one case, the next adjudication will require the knowledge of a physicist, an electrician, an engineer, and so forth.

What would any judge say of a chemist or a mathematician, or an engineer, totally ignorant of the practice of law, who tried to conduct a law case in court? Such an amateur lawyer might succeed in doing so, but to what hopeless loss of time, misunderstandings, and confusions would this lead before the subject had been mastered to some extent. Yet this is exactly what happens with a judge to whom we entrust to decide on the validity of a patent involving highly intricate scientific or technical subjects.

Judge Hand expressed himself very eloquently on this subject:

"I cannot stop without calling attention to the extraordinary condition of the law which makes it possible for a man without any knowledge of even the rudiments of chemistry to pass upon such questions as these. The inordinate expense of time is the least of the resulting evils, for only a trained chemist is really capable of passing upon such facts, *e.g.*, in this case the chemical character of Von Furth's so-called "zinc compound," or the presence of inactive organic substances. In Germany, where the national spirit eagerly seeks for all the assistance it can get from the whole range of human knowledge, they do quite differently. The court summons technical judges to whom technical questions are submitted and who can intelligently pass upon the issues without blindly groping among testimony upon matters wholly out of their ken. How long we shall continue to blunder along without the aid of unpartisan and authoritative scientific assistance in the administration of justice, no one knows; but all fair persons not conventionalized by provincial legal habits of mind ought, I should think, to unite to effect some such advance."

(See Parke-Davis & Company vs. H. K. Mulford Company, Circuit Court, Southern District of New York, April 28, 1911 —189 Federal Reporter, 95.)

Even under the new rules, it will not be difficult to drag on a case by presenting an unrestricted amount of testimony taken before an incompetent examiner, and by calculating every step so as to tire out your opponent, and so as to induce the judge in doubt and error, by swamping him with endless contradictory expert testimony calculated to befog the issue instead of making it clear. Such tactics are relatively easy for the litigant who, for that purpose, can afford to pay accommodating experts and skilful lawyers. Even if at the end, the judge, after laborious and conscientious efforts, masters the technicalities of the case and reaches a good decision, much needless time has been wasted. All this might easily be avoided, and judges might be saved the trouble and responsibility of going in every single case through a different scientific or technical training, if their intervention could be limited to what they are more competent for, namely, to determine what claims of patents have been infringed and in how far this infringement entitles the patentee to damages.

German Practice of Settling Patent Suits.

That such a method of settling patent suits is quite practical, is shown by the example of Germany. In that country, patents are allowed after preliminary examination, just like here; but, after the patent is granted, it can be attacked for annulment or revocation before a competent court in the patent office. So that any party who is sued for infringement of a patent which he thinks is invalid, can avoid temporarily the adjudication of the infringement issue by starting an annulment or revocation suit. In the meantime, the courts in which infringement cases are examined have to take the patent as it stands, and it is only left to them to interpret the scope of the claims, and to what exent these claims have been infringed.

This relieves the equity court of all the complicated questions of validity or non-validity of a patent, and puts this whole matter in the hands of a properly constituted court of experts who can handle this subject with incomparably less hesitation, or delay.

Besides this, the whole system of practice in the German Patent Office, tends toward systematic elimination of invalid patents. After an examiner has decided upon preliminary allowance of a patent, the claims and specifications are open for public inspection, and for a period of two months, anybody whosoever can file arguments against the final grant of the patent. In this way, the nation does not confer too lightly patent privileges and has furthermore, the benefit of the free advice of any experts in the art, who may advance good reasons for non-allowance of the claims, of which the examiner was not aware, when he rendered his first decision.

These opposition proceedings give added thoroughness to the work of the examiners. They are relatively inexpensive and do not ncessitate the intervention of law counsel. Sometimes they delay the issue of a patent, if there is any good reason for doing so. On the other hand, a patent that has successfully withstood vigorous opposition proceedings is very much strengthened thereby; this, in itself, is a very valuable compensation for any delays to which the patentee may have been subjected. In other words, by that system, a good patent becomes stronger, while a defective patent application is easily weeded out. A similar system of public opposition exists here in the United States in relation to the granting of trademark rights, and seems practical enough that it could be extended to our methods of allowing patents.

Such a sifting process, first by the examiner, then by opposition proceedings, sometimes by annulment or revocation proceedings, for wrongly issued patents, involves no serious difficulties nor great loss of time if carried out by courts of experts. Thanks to such a system, the work of a judge who acts on an infringement case, gains considerably in dignity and is, at the same time, enormously shortened and simplified. (See Wertheimer, The German Patent System, Electrical World, May 18, 1912.)

Proposed Changes of American Patent Office.

The German system throws the burden of technicalities and expert knowledge on the patent office, or the courts connected therewith. Nothing would be easier than to introduce a somewhat similar system in our country:

All officers of our patent office, high or low, should be made independent of any political favoritism; they should be better paid, with more opportunity for promotion, according to merit; their work should be made simpler by an improved office equipment and increased facilities for a thorough search; furthermore, our unnecessarily complicated and expensive methods of interference proceedings should be simplified.

With these reforms, there is no doubt that we can organize right in the patent office, a competent court, supplemented by the court of appeals of the District of Columbia, for deciding in a very expedient way, all questions of validity of patents.

This court of appeals, because it is situated right in Washington, would have easy and immediate access to all the records of the patent office; by this fact alone, it would have superior opportunities for prompt and efficient work.

During the late years, Germany has been trying to broaden its patent laws more and more toward the principles set forth in the American Constitution. For instance, it has practically eliminated the system of compulsory licenses except in some rare instances where public welfare is involved. If only we could borrow some of the more efficient methods with which the German patent law is administered and enforced, we might succeed in making an American patent *real* property for poor and rich alike, instead of a pretext for expensive and endless litigation with all the advantages it gives to the richer litigant, to the detriment of the consumer, who in the end, pays the bill.

Deficiencies of Proposed Oldfield Bill.

At least some of these facts seem to have been very well recognized in the masterly report of Hon. William A. Oldfield, chairman of the House Committee on Patents. (See report No. 1161, on H. R. 23,417, Aug. 8, 1912.)

Unfortunately, his proposed Oldfield Bill (H. R. No. 23,417) with a regrettable lack of consistency, neglects utterly the paramount issues, and busies itself with secondary regulations which if carried out will practically put a penalty on patented articles.

The new provisions of the Oldfield Bill aim at curtailing the power of patents in the hands of trusts or large corporations; but, in doing so, new provisions are introduced which will create endless new opportunities for protracted litigation.

The Oldfield Bill overlooks the axiom that whatever increases the expense or delays of litigation, is a very potent weapon in the hands of large corporations, which they can hurl against the poor litigant who stands in their way.

The saddest thing of all is that the new Oldfield Bill tries to abrogate the hitherto accepted principle established by our Constitution, that a patentee has the right to license or sell his patent on whatever terms he pleases. It has been feared that this principle, if carried too far, might become a dodge for avoiding anti-trust laws. Since the decision of the famous, but harmless, Dick case, the most hysterical exaggerations have been published on this subject. Fortunately, since then, the recent and unanimous decision of the United States Supreme Court in the "bath tub trust" case, Nov. 18, 1912, does away with all these redundant arguments and settles, beyond doubt, the principle that, patent or no patent, unlawful combinations in restraint of trade, can be stopped by the Sherman Law.

A Penalty on Patented Articles.

The Oldfield Bill, in its eagerness to avoid any hesitation on this subject, goes one step further, and unfortunately one step too far. It puts so many restrictions on the sale of a patent article, or on a patent license, that it may become a positive disadvantage to transact business by means of patents.

Examined in last analysis, it threatens a business based on patented processes or patented articles, with penalties which unpatented articles thus far are not subjected to. It takes the proposed patent law as a pretext for saddling a patented article with restrictions which have not heretofore been formulated for non-patented goods.

This unexpected paradox, promoted by the Oldfield Bill, is distinctly in opposition of the rights of intellectual property conveyed by the words and the spirit of the Constitution, and if the Oldfield Bill becomes an effective law, it will be the saddest blow ever given to our patent system. It will do comparatively little harm to large business interests, because for them, there are many ways of circumventing its provisions; on the other hand, it will cause great discouragement to smaller enterprises who, until now, have held the hope of matching inventive genius and initiative against the money power of big organizations. Make a large corporation respect the patents of a small concern, or of an individual, and you reduce at once any advantage of size or money power, and at the same time, you encourage the most beneficial form of competition, competition based on improvements. But to introduce curtailing restrictions for the licensing or selling of patented articles or patented processes to which non-patented articles are not subjected to, means simply obliterating the value of patents while needlessly increasing still further the opportunities of endless and ruinous litigation and chicanery.

Suppression or Non-Use of Patents.

Another unfortunate miscarriage of purpose in the Oldfield Bill is its provision against so-called wilful "suppression" or "non use" of patents. It does not take into consideration that in numerous instances, a patentee or an assignee possesses a series of so-called alternative patents, which can be used to bring about identical or similar technical results by modified means. Among such alternate patents, the best or the most suitable is used, absolutely irrespective of any other reason or intention to suppress their use. Yet without the exclusive possession of every one of these patents, the invention would not sufficiently protect against competitors, and the field would be so much reduced as not to make it worth while to put one's best energies to the development of the invention.

In most cases, it would become a material impossibility for a small concern to maintain the exclusive ownership of its patents, if it had to go to the enormous expense of working simultaneously all its "alternate" patents; by omitting this expensive technicality, it would be exposed to the risk of being compelled by its competitors to grant a compulsory license; this would practically annihilate the advantage of exclusive ownership as expressed by the Constitution.

There again large concerns would be at an overwhelming advantage because they can at an expense relatively small for them, equip the necessary appliances for remaining within the technical provisions of the law. In the meantime, they could easily harass their financially weaker competitors in exacting from them compulsory licenses which would break up the only prospects of successful competition which the smaller concern might have possessed, until then, in its patents.

In other words, the Oldfield Bill is aiming at the petty side of the situation, and in doing so, has unwittingly picked out a vital spot of our patent system. It reminds one of the man who set his barn afire in order to drive out a hornet's nest.

I have no doubt that this bill has been framed with the best intentions for the interests of the country. Unfortunately, the framers of this bill do not foresee the far-reaching and dangerous effects of its provisions.

One-Side Popular Conception of Inventions.

The average man, even the average legislator, has a rather one-sided conception of patents or inventions. Most people's idea of a patent does not go far beyond some simple mechanical device, like a patented mole-trap, a safety razor, an alarm clock, or other similar invention, more or less easy to understand after the apparently simple mechanical principles have once been explained. Then everything seems so simple and easy to them, that their limited imagination cannot conceive how even these apparently simple devices have frequently cost incredible efforts and immense amounts of money before their advantages became available to the public.

This attitude of mind develops, naturally, the belief that a patentee has a "soft snap," the result of a lucky idea, in about the same way as a lucky prospector strikes a rich gold mine, or a lucky ticket draws the grand prize in a lottery.

Precisely on this account it becomes difficult to explain to such people the rights and purposes of intellectual property; it is still more difficult to convince them that the nation is greatly benefited by liberal patent laws.

When it comes to chemical patents, the ignorance of the average public is amusing if not pathetic. Since we have heard a New York alderman in an official address of welcome to members of the International Congress of Chemistry speak as if they were druggists or pharmacists, we must no longer be astonished if the average Congressman or Senator refers to a chemical patent as a synonym to "patent medicine."

The Far-Reaching Effect of Chemical Inventions.

But even to the better prepared legislators, it is difficult to understand how some chemical inventions have brought about the most far-reaching developments, not only in other industries and arts, but on civilization itself.

For instance, it is not so obvious to them how processes for fixing the nitrogen of the air or extracting soluble potassium salts from rocks, enable us to make food supplies independent from the restricted potash mines in Germany or the nitrate deposits in Chili. Such inventions are no more nor less than means for preventing possible starvation of our race.

Do they realize that the development of the automobile, with all what it directly and indirectly implies, was entirely dependent on Goodyear's vulcanizing process of rubber?

Shall we remind them of the fact that without the invention of explosives, like dynamite, gigantic engineering enterprises, the Panama Canal, blasting of rock for the excavation of our cities, mining for ores, tunneling and grading of railroads, would be impossible?

How could we expect even the most perfected modern printing presses to distribute to every citizen, rich or poor, young or old, that knowledge and culture, which means better citizenship, better opportunities for happiness and development of our race, if it were not for the inexpensive and abundant supply of paper furnished by the cellulose processes. The Greeks, the Romans, and even the Middle Ages had their sages, their poets; yet those were the times of slavery and oppression, because knowledge was only in the reach of such a limited number that it was possible for tyrants to throttle its diffusion by sending the few advanced thinkers to the gallows or burning them alive. For the same reason, scarcity of books, the destruction of the library of Alexandria, was a calamity for the intellectual development of mankind. Our abundant supply of cellulose makes a repetition of such conditions an utter impossibility.

Then, again, where would we find our supplies of steel, the main raw material for modern engineering, if the Bessemers, the Thomas-Gilchrists and others had not invented their processes? How about the marvelous synthesis of products derived from coal tar, which have literally created the most astounding series of new substances which have revolutionized therapeutics, surgery, hygiene, and are finding daily new applications in the most varied arts and in general technology?

The Increased Cost of Living in Its Relation to Invention and Patents.

At a time when all countries are confronted with that critical question of the increased cost of living, it may be interesting to point out that just those industries where invention and patents have played the smallest rôle are also those where the increase of price is most burdensome, while those commodities where patented inventions have had the fullest influence have, on the contrary, decreased in price, and in some instances, to an astonishing degree.

For instance, the price of sulphuric acid is about fifteen times less than it was in 1807 and about one-half of that of 1870. The price of soda ash is about one-sixth of what it was in 1823, and about one-half of the price in 1860. Nitric acid sells for less than one-half the price of 1861. Glycerine sells for about one-eighth of the price in 1855. Chloride of lime in 1800 sold for 30 cents a pound, in 1870 for about 2 cents per pound, to-day for about 1 cent a pound.

Any chemist knows that every one of these products is used directly and indirectly in the most ramified channels of our arts and industries, but the layman does not know that cheap soda means cheap soap, cheap paper, cheap glass, etc.; that cheap sulphuric acid means cheap fertilizers, better crops, cheaper corn, cheaper wheat, and so forth.

Let me point out that the decrease in price of these materials is even considerablly greater than the bare comparison of figures indicates, if we take in consideration that the purchasing value of money has considerably decreased, while the cost of labor has enormously increased.

Nor are these examples merely confined to chemical products. The reduction in price for articles where patents have played an important rôle is just as evident in steel products, tools, machinery, etc.

Compare these lower prices with the vastly increased cost of rents, clothing, foodstuffs, and many agricultural products, where patents have played a less preponderant rôle. If you will carry your analysis still further you will find that in such branches of trade where patented inventions have had little or no importance, for instance, cattle raising, prices have soared highest. On the other hand, for such agricultural products where patented machinery could be used to best advantage, like wheat and corn, the increase of price has been relatively small. Then, again, garden vegetables, potatoes, etc., where the use of patented agricultural machinery is less available, show an enormous increase in price.

You may object that the price of shoes has gone up, but here again, the increase is entirely due to the greatly advanced price of hides, and were it not for the perfected shoe-making machinery, and for the better and cheaper chemical tanning methods, all due to patents, the cost of our shoes would be so high that they might again become an article of luxury, available only for the well-to-do.

The present price of clothing is high enough as it is; nevertheless, it would still be much higher but for the patented machinery for spinning and weaving, the patented chemical processes of bleaching, dyeing, mercerizing, etc.

I should not omit to mention our vastly improved and cheapened methods of transportation, of production of power and light, all developed and perfected on an interwoven system of patents; I could explain the far-reaching influence thereof on civilization, culture, on the happiness and security of life of the individual citizens; but even then I might not convince the pessimist or the scoffer who only sees the hole in a doughnut and stubbornly persists in ignoring the doughnut itself.

The Genesis of an Invention and the Incentive of a Patent Property.

The history of almost every invention which we a[re] ing now, unconsciously, every day, is an epos by itself, the details of which are only known by the few pioneers who gave the best they had to give, who helped with their brains, with their money, and talent of organization; some with their very lives.

The oft repeated statement has been made: "An inventor cannot help inventing, whether you give him a reward or not." Then again, some others say: "Necessity is the mother of invention."

The most apparent fact is that the man who receives an ample income from his father, or some other privileged source, is less prompted to distinguish himself by arduous creative work on inventions than the poor but intelligent man who sees in invention a means of making himself financially free and independent, as well as giving an outlet to his inventive abilities.

Whoever has followed intimately the development of some chemical processes knows very well that whether "the inventor cannot help inventing," or whatever may be the incentive to invention, most of these important inventions could never have been carried out, or could never have been brought to the point where they became of public benefit but for the intelligent use of vast sums of money.

Too few people have a conception of the immense sacrifices, of the serious money risks, involved in the development of some patents. Many chemical inventions used now currently and open to the public at large have cost millions before they were brought into practical shape or before the public was educated to their advantages. Can any one expect that such expenses, such efforts, such risks would be undertaken unless there was the possibility of at least some chance of recouping by a temporary patent protection?

The Large German Chemical Corporations.

Let us take, for instance, those large German chemical companies, which employ hundreds of chemists and engineers, engaged exclusively in research work; to them we owe the development of many processes which have had an untold beneficial influence in many directions of the economics of our daily life, even on civilization itself.

They employ large aggregations of capital, reaching into many millions. The dividends of some of these companies may appear large to the superficial observer. Yet if you look more closely into it you will find that these very companies were founded long ago, some of them over half a century or more, that the large capital which they employ has never been "watered," that, although they have had the benefit of the devoted co-operation of an endless number of distinguished men, stars of first magnitude in their profession, the net returns on their invested capital, at the end of half a century of brilliant intellectual pioneer work, is relatively small, even if the dividends seem large. In fact, the net returns are decidedly lower than that of many American enterprises not over fifteen years old, and where progressive technical leadership was entirely lacking, but where tariff privileges and agglomeration of competing concerns into a trust insured a splendidly paying monopoly, notwithstanding the reckless financiering of their promotors.

If you will further investigate the history of those German chemical concerns which have become leaders of the industrial world by nothing but their intellectual pioneership, you will find that notwithstanding all the patents on which they have to rely the expenses involved in research work and pioneership, swallow up, to a large extent, the profits realized in some of the established branches. But with true scientific spirit their far-sighted directors were willing to sacrifice a very considerable part of their earnings in their search for improvements and development of new ideas; they have set a magnificent example in the only competition beneficial to the public—*competition by improvement.*

One of our wealthiest retired multi-millionaire manufacturers, not so long ago, speaking about his money successes, gave the following advice: "Never be a pioneer; it does not pay. Let the other man do the pioneering, and then after he has shown what can be done, do it bigger and more quickly; but let the other man take the time and the risk to show you how to do it." To any one who advances the statement that an inventor "cannot help inventing," I desire to ask whether an inventor will do much inventing, if in order to carry on his research work, or to develop his intention, he has to spend hundreds of thousands, nay, sometimes millions of dollars, but does not possess them, and nobody is willing to take the risk to furnish the money unless there is a fair chance for his backers of obtaining some compensation by a temporary patent protection? Those who know the large sums of money which have been swallowed up by the research and development work connected with the artificial production of nitrates, with the Solvay soda process, the development of the steam turbine, electric light, electric traction, and numerous other inventions of far-reaching magnitude, will know what I mean.

Just on this account it is highly unreasonable of the Oldfield bill to try to make a distinction between the inventor in whose name the patent is drawn and the party who runs the risks in enabling the inventor to make the invention available to the public; any such legislation simply tends to discourage those who, at considerable risk, furnish the capital and the talent to develop an invention into a commercial possibility, and who thereby bring it into real public service.

The Gap between Invention and Commercial Success.

Now and then I have perceived that some of my fellow chemists, who, although highly trained, have never created anything of technical value and whose experience with matters of practical life frequently extends not beyond the confines of their lecture room or their laboratory, do not seem to grasp fully the immense distance that lies between the initial conception of an invention, or its study in the laboratory, and the overwhelming amount of careful work and money risks connected with its development on a commercial scale, until it has safely reached the point where the public can avail itself of the invention.

I wish to cite, for instance, the famous Solvay process, which gives us cheap, excellent and abundant soda, an article of prominent importance in the wheels of our civilization. This process was known and described more than a dozen times, and had even been tried repeatedly at considerable loss, on a commercial scale, many years before Solvay tied his genius to this difficult problem and developed from an unreliable laboratory reaction a process of great industrial importance; then, with a staff of able collaborators, and the employment of large amounts of cash, he overcame, by and by, the technical drawbacks which had caused the failure of all of his predecesssors.

Hundreds of similar examples could be cited. Whoever has been intimately acquainted with the commercial development of some of the most successful inventions knows quite well the risks, dangers of failure, which have accompanied the herculean task of development and educational work. It is a well-established fact that the great majority of new enterprises fail, that few succeed.

The Educational Effect of Inventions.

The educational effect due to the introduction of patented inventions is of immense benefit to the public, although this fact is not very apparent to most people. In many instances the owner of a patent frequently has to go to extreme sacrifices before he succeeds in convincing the public of the merits of his invention; in fact, the public stubbornly refuses to benefit by an improvement to which it has not been fully educated.

The practical value of cash registers only became obvious after a most thorough and expensive educational campaign.

The metric system is just as useful as the cash register; it was invented long ago and systematized in all its details during the first French Republic. Nevertheless, to-day, there are still two large commercial countries, the United States and England, which have not yet been educated to its merits; if the metric system had been patented, like the "cash register," somebody, during the seventeen years of the patent monopoly, would have undertaken the money risk and arduous task of thoroughly explaining the advantages of the metric system to our conservative citizens, and we would have ceased long ago to submit to the burden of waste of time and money caused by our antiquated, cumbersome system of weights and measures.

It has been stated, with much reason, that the best way to postpone the benefits of an invention is to allow public use of a patent, because then nobody takes the risk of starting an educational campaign or of developing the invention, which, after all, means pullling the chestnuts out of the fire for the benefit of others.

Entirely new industrial enterprises are not easily started on inventions which are not patented, unless some other method is available for insuring some kind of a monopoly; for instance, by maintaining secrecy or by acquiring special skill, or by controlling the raw material, or by tying the market, or, in other instances, where the initial outlay for a plant requires a capital so large as to exclude others.

Moreover, if you scrutinize those industries where secrecy of methods, instead of published patents, is the prevailing tendency, you will find that the secret-process industries are precisely those which have least progress to record and where high prices rule.

Whoever desires to get posted on the modern literature pertaining to any industrial chemical processes will find that available text-books are many years behind in information as far as novelty and accuracy are concerned; for this reason alone, it is absolutely indispensable to get acquainted with all recent patent literature.

Were it not for the compensation expected from patent rights most of this information would be carefully kept secret, or, if it were divulged at all, this would mostly occur by accident. Every newly published patent sets to work the thinking cells of numerous inventors, who are not slow to suggest further possible improvements. Every patent of some importance is rapidly followed by a succession of other patents conceived by other inventors who were inspired by their predecessors, and so the work of progress goes on unceasingly and at a quickened pace.

In the age of the alchemists there were no patents; inventions and discoveries were jealously guarded and buried with their originators, and the world and its inhabitants remained very much what they were, with most rights and comforts in the possession of those in power, and very little chance of improvement for the non-privileged classes.

What Can Be Done?

The public should be educated in these truisms. Unfortunately, the education of the public has been directed in the opposite way since patent infringers have utilized the daily press after the late decision of the Supreme Court in the Dick case to start a campaign for urging our well-meaning but ill-prepared legislators towards patent reform, which will give still broader scope to our modern buccaneers. This reminds of the man who, after stealing a stranger's pocketbook, kept on shouting "stop thief," so as to distract the attention from himself.

Two ways are open for our legislators:

One way is to try "to hit the trusts" by mutilating the best there is in our patent system, which has been such a potent factor in the development of our country; to chill the best incentive for private enterprise; to stunt that kind of competition most beneficial to the public, competition by improvement, incomparably better in this respect for stimulating industry, science and progress, than protective tariff privileges which, in many instances, have worked in the opposite direction.

The other way is not to put dangerous restrictions on the patent rights defined by our Constitution. If there has been any fear that such patent rights might be abused for evading the provisions of the anti-trust laws these apprehensions have vanished by the clear, unequivocal decision of the Supreme Court in the bath tub case.

But there is urgent need of reform in our patent system by simplifying procedure in the Patent Office as well as in the courts by insuring better, quicker, and less expensive means for adjudicating the title and validity of patents. Only such a reform will bring about that big or small, poor or rich alike may be stimulated by the advantages of our patent system, instead of making a patent an expensive but powerful instrument available only to the wealthy.

Whatever simplifies and lessens the cost of the administration of our otherwise excellent fundamental patent law gives the enterprising man with small means a better chance of competition by inventive progress and merit against ponderous aggregations of capital. By such reform, which insures such healthy competition, the nation is sure to be benefited.

In all above considerations my remarks were principally inspired from the standpoint of chemical patents, not alone because this very important class of patents is least understood by the average public and the legislator, but because chemical process patents are also those which are most difficult to protect them from infringers.

The University of Pittsburgh is undertaking an investigation of the smoke problem, and has issued *Bulletin* No. 1, containing an outline of the work.

The indexing of mining literature receives attention in the *Quarterly* of the Colorado School of Mines, Golden, Colo. Carl A. Allen, assistant professor of mining, has completed an extension of the Dewey Decimal System of Classification as applied to mining.

Semi-Automatic Furnaces.—The W. S. Rockwell Company, of 50 Church Street, New York, has issued illustrated catalog 16 on the Rockwell semi-automatic furnaces for annealing, hardening, tempering, heat treating and miscellaneous heating operations. This type of furnace has been developed to provide a means of uniformly heating large quantities of material of irregular shapes and sizes and which cannot be well handled by an automatic furnace of the rotary or conveyor type nor as economically heated by the ordinary stationary furnace. The "semi-automatic" furnace is of the stationary form, but the material to be heated is conveyed through it mechanically in a continuous or nearly continuous manner.

Measurement of Temperature by Electrical Means.*

By Chas. Burton Thwing, Ph.D.

The measurement of temperature, as compared with the measurement of other physical quantities, is beset with many difficulties, since temperature is a quantity which cannot be directly measured, as are length and weight, but must be inferred from the change in various physical properties, either of the body itself whose temperature is to be measured, or of other bodies in contact with it.

The changes, for example, in volume of the standard body, or thermometer, as it is called, for each temperature in its range, having been previously determined, the body and the thermometer are brought in contact and allowed to remain in contact until they have reached thermal equilibrium, when the temperature read from the thermometer is assumed to be the temperature of the body. It often happens, however, that both the body and the thermometer are immersed in a medium whose temperature, like the air of a gas furnace, is changing rapidly. In this case, if the body is large and the thermometer small, the thermometer will respond more quickly than the body and give false indications of the temperature of the body.

One of the earliest methods of comparing temperatures is still, for many purposes, one of the most accurate and convenient, i.e., the change in volume of a liquid, like mercury or alcohol, contained in a glass bulb, terminating in a slender tube. There are certain circumstances, however, under which the mercurial thermometer fails to meet all the requirements; first of all it is not suitable for measuring high temperatures; secondly, it is often inconvenient or impossible to so place the thermometer that it is in contact with the body whose temperature is to be measured, and at the same time accessible to be read; thirdly, it is not at all well adapted for making a graphic record.

The various types of electrical instruments for measuring temperature have proved very adaptable over a wide range of temperature, in the most inaccessible situations, and are admirably adapted to produce graphic records at any distance. The increasing use of such instruments, both in research work and the numerous lines of industrial operations, makes it desirable that engineers should be informed as to the general principles on which electrical temperature measurements are based, and that they should have some notions as to the availability of the different types of such instruments best suited to various conditions.

Leaving out of the question certain optical pyrometers, in which an electrically heated body is used for color comparison, there are three different types of electrical instruments used for measuring temperatures: (A) the simple thermocouple, connected to an indicating or recording galvanometer; (B) the radiation type, consisting of a device for collecting the rays at the junction of a sensitive thermocouple, which is connected to an indicating or recording galvanometer; (C) a resistance which varies with the temperature, used in conjunction with a suitable indicating or recording potentiometer or millivoltmeter, for measuring the variations in resistance, which may be either in the nature of a Wheatstone Bridge or a direct reading ohmmeter.

I shall proceed to describe the three types of instruments in the order named, and then discuss briefly the suitability of the various types for making measurements under some of the varying conditions which occur in practice.

Simple Thermocouple.

In the Type A instruments, the thermocouple is composed of two wires or rods of unlike metal, securely joined together, by twisting, riveting or welding, at one end, this junction being known as the "hot junction," and connected at the free ends to copper leads which convey the current to the millivoltmeter, the scale of which is ordinarily graduated in degrees of temperature, or, in other words, is "direct reading." This point of connection between the elements of the thermocouple and the cop-

*A discussion before the Philadelphia Section of the American Institute of Electrical Engineers.

per leads is commonly referred to as the "cold ends" of the thermocouple.

Only a limited number of metals is available for use as thermocouples, since the thermoelectric difference of potential is small for some of them. The choice narrows down in practice to copper, iron, nickel, and platinum, and the alloys of nickel and platinum. The first thermocouple to be employed was that known by the name of LeChatelier, consisting of platinum for the negative against platinum-10 per cent iridium for the positive element. The platinum-iridium alloy is at present almost wholly displaced by the use of platinum-10 per cent rhodium, which, although it gives a somewhat lower e.m.f., is more constant under continuous use for high temperatures.

The platinum thermocouple may be used for temperatures as high as 1600 deg. C. (3000 deg. Fahr.) for short intervals, but under long exposure, even when protected in the best porcelain tubes, the evaporation of the platinum at the "hot junction" and its absorption by the platinum-rhodium gradually reduces the emf of the thermocouple. Moreover, the failure of the porcelain tube to prevent the access of various contaminating gases to the platinum thermocouple permits in time such alterations in the couple as to necessitate frequent recalibration. The high cost of platinum makes it necessary to use very small wires, a circumstance which not only aggravates the faults above mentioned but introduces errors of considerable magnitude, due to the varying resistance of the thermocouple when immersed to varying depths in the heat.

These considerations led to the search for base metal thermocouples, some of which have proved to be, in many respects, superior to the platinum thermocouples for temperatures up to 1000 deg. C., at least. For the positive element of such thermocouples, which are to be used for temperatures as high as 1100 deg. C., an alloy of nickel with 6 to 10 per cent chromium is one of the most suitable. For the negative element, a nickel alloy with a small percentage of various other elements is used. This thermocouple has an emf about 3½ times as great as the platinum thermocouple at 1100 deg. C. (2012 deg. Fahr.). These materials are, moreover, so much cheaper than platinum that the thermocouple can be made of larger size, thus eliminating very largely both the error due to the surface contamination of the elements and the error due to the varying resistance with varying depths of immersion. The latter error is still further reduced by the fact already mentioned that the emf of the couple is higher, thus permitting higher resistance in the galvanometer.

Where the maximum temperature does not exceed 900 deg. C. (1652 deg. F.), a nickel alloy consisting of about 41 per cent nickel with 59 per cent copper, used as the negative element against the above mentioned chrome-nickel alloy, or either copper or iron as the positive element, gives an exceedingly constant emf as well as a very high one; the emf being about six times that of platinum, at 900 deg. C., and exceedingly constant even after long use. This alloy, which is known as constantan, has the added advantage over platinum of having a very small co-efficient of resistance even for high temperatures, so that the error due to the varying depth of immersion of the thermocouple becomes practically negligible. The high emf of this couple makes it especially suitable for low temperature measurements; indeed, for all temperatures below 900 deg. C., it is preferable to platinum for thermocouples, even though there were not the difference in cost.

Limitations of Thermocouples.

The extreme simplicity of the thermocouple makes it one of the first means to be considered when electrical temperature measurements are to be made. It has, however, two faults; first, the quantity of energy available is small, so that the millivoltmeter employed must be much more sensitive than the electrical instruments employed for most commercial purposes. The emf of the platinum thermocouple is but 18 millivolts at 1600 deg. C. (2912 deg. F.) and that of the nickel thermocouples but 60 millivolts at their respective highest ranges. With the best modern designs of millivoltmeters there is, however, no difficulty in making accurate instruments to measure the small amount of energy available, except where the range of temperature covered is small. Under these circumstances, it is sometimes best to use a number of thermocouples in series, though it is often preferable to adopt the resistance type of instrument, especially if the temperature is low.

The second objection is a more serious one, where measurements are required to be of extreme accuracy, and most serious when the range of temperature is small. This is known as the "cold-end error." It must be borne in mind that the emf which is measured by the galvanometer is a quantity which varies with the difference in temperature between the hot junction and the cold end of the thermocouple, or where the copper wires leading to the galvanometer are joined to the elements

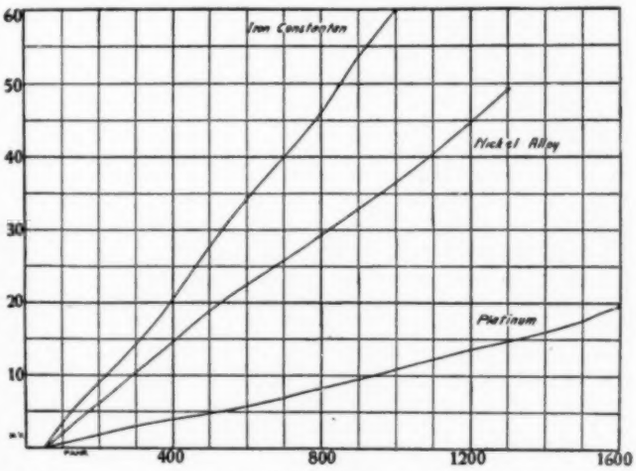


FIG. 1.—E. M. F.—TEMPERATURE CURVES FOR THREE TYPICAL THERMOCOUPLES.

of the thermocouple. If the instrument is calibrated for a "cold end" temperature of, say, 25 deg. C. (80 deg. Fahr.), it will read too low if the cold ends are at 30 deg. C., and too high if the cold ends are at 20 deg. C. It is quite commonly possible, where high temperatures are to be measured, to place the cold end at a point near the floor, or underground, or in contact with steam or water pipes, so that it may be maintained at a temperature which will not vary far from a standard fixed temperature. Of course, it is possible, when special refinements of temperature measurement are required, to observe this cold end temperature and make the necessary correction for it. In

FIG. 2.—RADIATION PYROMETER.

research work, or for calibration, the cold ends are immersed in ice water.

The curves shown in Fig. 1 illustrate the temperature e.m.f. relation of the three typical thermocouples mentioned above.

Radiation Pyrometer with Thermocouple.

Type B is available for temperatures which are too high for platinum thermocouples, or for situations not easily accessible, even where the temperatures are not too high, as, for example, in a large furnace, or at the surface of materials in motion, such as masses of steel passing through rolls or under the hammer. In this instrument, use is made of the law connecting the total energy radiated by a body with its temperature. This law is known as the Stefan-Boltzmann Law, and is expressed in the equation $E = K (T^4 - T_1^4)$ where E is the total energy radiated by a body of absolute temperature T, and K is a constant depending on the units used. This law has been found to hold not only for the highest temperatures measurable with gas thermometers and thermocouples, but has been found to give

results in perfect harmony with measurements made by employing optical pyrometers, in accordance with the law of Wien, as high as 2600 deg. C. (4712 deg. Fahr.).

The method consists, as stated, in collecting all the radiations, both luminous and non-luminous, from a limited area of the body whose temperature is to be measured and concentrating them upon the blackened junction of a sensitive thermocouple. In the form employed by Féry, the rays are collected by means of a concave mirror, and are focused upon the junction of the thermocouple by means of an ingenious optical device, contained in an eye-piece attached to the telescope.

In the simpler form devised by the writer, the radiations are concentrated by means of a conical aluminium mirror. Since the radiations are transmitted down the conical mirror by means of multiple reflections, as shown by Fig. 2, the mirror is equivalent to a fixed focus mirror, for the rays entering the cone through the diaphragm are transmitted to the outlet, and strike the thermocouple, regardless of whether or not they are parallel on entering the cone. This makes the instrument exceedingly convenient to use in foundries and rolling mills, and other places where the quick motion of the men would be interrupted by the use of an instrument which required mounting in one position for any length of time. The quickness of action of this instrument is further increased by the extremely small dimensions of the thermocouple, the heat capacity of which is so small that equilibrium is reached in five seconds after pointing the receiving tube of the instrument at the hot body.

This instrument has found application, both in the indicating and recording forms, for use in steel and rolling mills, steam boilers, smelting furnaces, and in the large rotary form of kiln used in cement burning and the nodulizing of iron ore. The portable form is used for taking the temperature of molten steel, both before tapping from the open-hearth furnace, as well as after tapping, and while pouring, and for taking the temperature of tools made of high-speed steel, in hardening furnaces, where it is desirable to indicate not so much the temperature of the furnace as the temperature to which the work itself has been heated. This type of instrument is not only capable of a high degree of accuracy in measurement but, since it is not exposed to any high temperatures, it deteriorates much less with use than any other form of electrical pyrometer.

Electric Resistance Pyrometer.

Type C, or the Resistance form of electrical pyrometer, has been employed for all ranges of temperature from that of liquid air to temperatures as high as 1100 deg. C. (2012 deg. Fahr.). For this higher temperature, the problem of protecting the resistance coil from mechanical damage, as well as from the contamination of the platinum by the presence of any foreign gases, becomes a very serious one.

The slightest admixture of any foreign material with platinum alters its resistance very appreciably, so that it becomes necessary to protect the coil both with a porcelain tube and an additional covering of nickel. The nickel protection, of course, is only durable at such temperatures as are the nickel thermocouples, and the whole bulb is much more expensive to install and maintain than the thermocouple.

For temperatures below 200 deg. C. (392 deg. Fahr.), resistance wire of pure nickel is employed. This has the advantage of low first cost and constancy in its indications over these low ranges of temperature. The coil is enclosed in a tube of varying shape and material, suited to the conditions under which it is to be used, and is capable of taking measurements comparable in refinement with those made by the best mechanical thermometers. The same bulb may be employed for measuring all temperatures from the transformation point of nickel, about 200 deg. C., to the lowest temperatures obtainable with liquefied gases.

When the bulb is used as one arm of a Wheatstone bridge, the galvanometer employed will only give accurate indications when used as a null instrument, unless provision is made for supplying a constant emf, in which case it may be used as a deflection instrument. The form of indicator most commonly used with the null method has a dial graduated to degrees under a pointer which moves a contact over an adjustable resistance.

Selection of Type of Pyrometer.

In the selection of the suitable type and form of instrument for measuring temperature under any particular conditions, the temperature range will be one of the first considerations. For temperatures with a maximum range above 1500 deg. C. (2732 deg. Fahr.), the radiation type is the only one of the three which is available. The lower limit for this type of instrument is ordinarily about 500 deg. C. (932 deg. Fahr.).

While the upper limit is 1500 deg. C. choice may be had between the radiation and the platinum thermocouple.

Where the upper range is 1200 deg. C. (2192 deg. Fahr.), the chrome-nickel thermocouple, the platinum thermocouple, and the radiation type may all be used.

For temperatures up to 1000 deg. C. (1832 deg. Fahr.), the iron-constantan thermocouple would come first in consideration, with the platinum resistance type also available.

For temperatures below 200 deg. C. (392 deg. Fahr.), the iron-constantan thermocouple and the nickel resistance could be employed, with the choice probably in favor of the resistance type.

The form and size of the thermocouple or resistance bulb would also be determined by circumstances. Where large heat areas are under consideration, with slow changes of temperature, the thermocouple may be of large cross-section, and thoroughly protected with iron or refractory tubes.

Where the bodies to be measured are small, and the temperature fluctuations are very rapid, the thermocouple must be made smaller. For example, if we are determining the transformation point of a number of specimens of steel, it is desirable that the specimens be small, with a small opening into which we may insert a very small thermocouple.

The same considerations which make the thermocouple small, would determine the choice of the thermocouple as against the resistance bulb, since the former can be made almost infinitesimally small, and will correspond with corresponding quickness to the temperature of the enclosing body.

Where thermocouples are used, the greatest consideration must be given to the matter of cold-end variation, and in the installation the most complete precaution must be taken in the matter of wiring, to make sure that all joints are permanently made.

In the case of resistance thermometers, the failure to get good results is often due to the failure to protect the lead wires from moisture or from abrasion. In fine, we must recognize that in general when making temperature measurements, we are handling a complex problem, and are dealing with electrical temperature-measuring devices which are sensitive instruments, requiring the application of judgment to obtain the best results.*

Philadelphia, Pa.

The South African Mining Journal recently celebrated its twenty-first anniversary by issuing a souvenir number. The issue contains historical data on Rand mining and milling, as well as a general survey of present conditions, and is in keeping with the importance of the special field covered.

The **Yarnall-Waring Company,** formerly at 1109 Locust street, Philadelphia, announces their removal to Chestnut Hill, Philadelphia, having assumed management of the factory and sales of the Nelson Valve Company. The identities of both companies will be maintained as before.

Electrical Show at University of Illinois.—An electrical show is to be held at the University of Illinois at Urbana, Illinois, on February 6, 7, and 8, 1913, under the auspices of the Electrical Engineering Society. This show is a triennial event and a university affair, conducted wholly by the undergraduate students, of interest to the alumni as well as to electric power users and manufacturers who will be allowed to exhibit.

*In connection with this subject the article by Dr. Northrup on the thermal e.m.f. of tungsten and molybdenum on page 45 of this issue will be found interesting.—Editor.

A New Type of Blast Furnace Construction

A paper read at the Cleveland meeting of the American Institute of Mining Engineers by J. E. Johnson, Jr.

The general construction of blast furnaces has undergone no radical change in more than a generation. When the old style of masonry construction was replaced by the steel shell, the masonry piers were simultaneously replaced by columns never less than six and frequently twelve or sixteen in number, set under the mantle ring. These columns were at first unvaryingly made of cast iron, but in more recent years have frequently been made of structural steel.

The furnace itself has recently been the subject of radical changes; in some cases the thin-lined construction has been adopted for the whole furnace, and in other cases has been adopted for a zone immediately above the bosh, raising the mantle several feet to make this possible, but still the style of construction with columns set immediately under the mantle has been universally followed. In spite of the apparent permanence of this type of construction it is open to grave disadvantages from the operating point of view, which may be briefly outlined as follows:

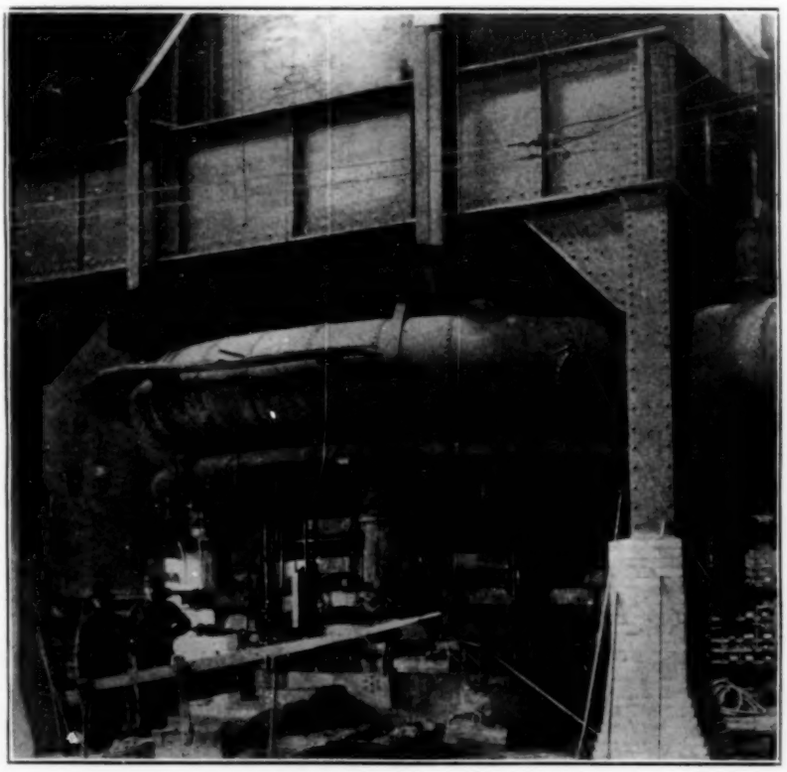


FIG. 1.—NEW TYPE OF BLAST-FURNACE CONSTRUCTION.

The bustle pipe is necessarily outside the columns as the slope of the bosh and size of the crucible are such as to leave but little room inside the columns for the necessary water piping, etc., consequently the penstocks have to pass between the columns. Moreover, the hearth jacket requires a diameter but little smaller than the circle of the inside of the columns, and as a result the cooling-water ditch for protection against breakouts is exceedingly limited in width. As a consequence of these conditions, when any work requires to be done around the furnace such as changing a tuyere or working on the cooling-water pipes, the amount of room left by the columns, penstocks and water pipes is more conspicuous by its absence than by its presence. Moreover, if a break-out occurs, the ditch is filled with iron, perhaps half way around the furnace, or more. This locks itself in between the columns and the hearth jacket in a way that not infrequently makes impossible its removal while in blast. I knew one furnaceman who declared that the proper thing to do with the ditch was to run the first cast of iron into it and let it stay there so as to save future bother.

Another result that not infrequently has followed break-outs is the burning and cracking of the columns by the molten iron and cinder surrounding them.

Still another result of this construction is less immediately disastrous, but leads eventually to a very serious condition. The space between the base of the columns and the hearth jacket being so small the whole structure is necessarily set on one foundation and the continual expansion, which all masonry structures undergo from continued heating, gradually pushes the column bases out. In some cases an effort has been made to resist this tendency by making a continuous sole plate, or ring, on which the bases of the columns rested, but I have never known a case in which these were not broken and some plants have abandoned their use altogether, using simply an individual base under each column on the ground that as they will break apart anyway it makes a neater job to make them separate in the first place.

I think all furnacemen have experienced these conditions and will agree to the general correctness of these objections to this construction.

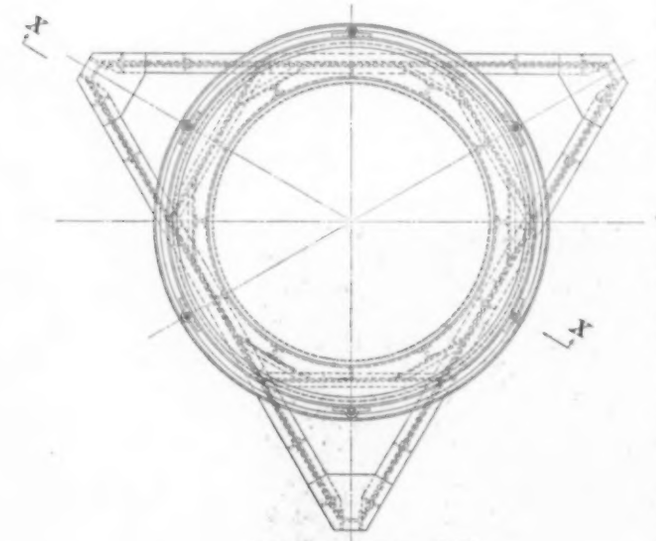
It had seemed to me for several years that it would be possible to avoid these evils by building a frame-work of structural material strong enough to carry the weight of the whole furnace and supporting this on columns set at the corners of this frame-work, which would throw them so far back from the furnace proper that they would be safe from all danger from break-outs or other accidents, and at the same time would allow room enough around the furnace for necessary access to all parts with great safety, ease and speed in all necessary work; and that if the ditch became filled with iron, this would be unable to lock itself around the columns, and, being free on one side could readily be removed.

When our investigation concerning the quality of charcoal iron had indicated the desirability of reconstructing the fur-

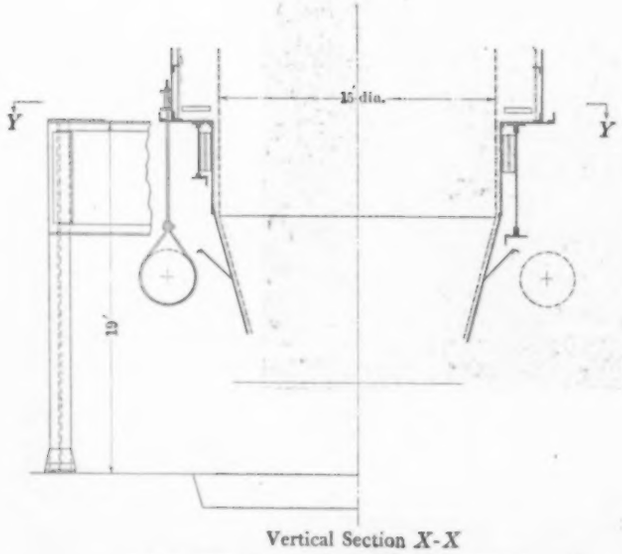
nace to obtain the lines needed, we laid out various plans for doing the work and this construction appeared to be so practicable from an engineering standpoint, and so desirable from an operating standpoint, that it was finally adopted.

We first laid it out with the idea of using a triangular frame of girders with a column at each angle, and in order to get the girders above the bustle pipe we considered using the thin-lined construction for several feet above the bosh angle and letting the mantle at the top of this thin zone rest directly on the girders. This is shown in Fig. 2.

But on further consideration there were two features of this design which we did not like. We desired to use the steel bosh jacket construction, cooled by external sprays which



Horizontal Section *Y-Y*



Vertical Section *X-X*

FIG. 2—HORIZONTAL AND VERTICAL SECTION.

has proven so durable and satisfactory at many plants in the South and at some in the North, and which avoids entirely the stepped bosh wall, almost as angular and rough as a flight of steps, into which the cooling plate construction soon wears.

When the bosh jacket construction is used it is necessary to realize that no matter how much brick may be laid on the jacket at the beginning of the blast, it will all soon be gone, and its place taken by a composition of carbon, slag, etc., held on the slope of the jacket by the water cooling. When this construction is adopted provision must be made for the fact demonstrated by experience that the bosh will expand downward from the mantle on which it must be supported and the crucible upward from the hearth, and consequently space must be allowed in which this expansion can take place without injury to the structure, without shearing off any water pipes, and in such a position that the crack formed by the expansion will be sealed by cinder as fast as formed. This thin skerf on the bosh jacket is obviously unsuited to support any brick-work above it, and, while the lining is self-renewing on the sloping surface of the bosh jacket, we were fearful that this would not be the case on the vertical or overhanging section above the bosh. We, therefore, thought it best not to adopt the thin-lined zone above the bosh.

In regard to the three-column construction, while it sets the columns back further from the furnace than does the four-column construction, and while three columns are theoretically enough to support any structure, still in the event of a serious accident around the bottom of the furnace, it was conceivable, even though, I think, highly improbable, that one column might be sufficiently affected by heat to yield, and with the three-column construction this would throw the whole furnace to the ground.

With the four-column construction on the other hand, if anchor bolts to hold the structure down to the foundation were used, one column could fail completely and the two adjacent to it would carry the structure with the assistance of the counter-weighting action of the column opposite to the one that failed. This, of course, would only be true if the columns were made so strong that any two would carry the structure.

Accordingly, the four-column construction was adopted and the columns designed to have an ample factor of safety with any two of them supporting the entire weight.

In order to raise the girders above the bustle pipe and at the same time avoid the high mantle possible only with the thin-lined zone above the top of the bosh, it was necessary to support the shell on the girders by brackets. In order to reduce the local stresses on the bottom of the shell, due to these brackets, as far as possible, eight of them were used. This also had the great advantage that by spacing the brackets so that the centers of the girders came half way between them the load on the girders was applied relatively close to the columns and the bending movement enormously reduced. At the same time the distance from the shell to the center of bearing on the base of the brackets was increased but little over what it would have been had they come on the center of the columns.

It is obvious that the mantle plate would be entirely unsupported except at its outer edge and that it might deflect at the inner edge, owing to the weight of the brick-work, if some provision were not made to prevent this.

The extent to which this action could occur in view of the brick being so firmly supported at the outside by the heavy angle riveted to the shell, is problematical, but it was not desired to take any chances and a cantilever bracket was therefore designed to support the mantle plate from below to within a short distance of its inner edge.

The angles which are employed to rivet the bracket to the shell are continued down below the mantle and support a heavy vertical plate, the inner end of which projects under the mantle plate, while the outer end is prevented from rising under the weight so applied by heavy angles fastened to it, which pass up outside the girder and take hold of the outer end of the shell bracket. It is obvious that the angles next the shell act in tension and those outside the girder in compression, making a very rigid support for the overhanging end of the cantilever under the mantle plate. In order to prevent any possibility of deflection of the mantle plate between these brackets, heavy channels were riveted to the inner ends of the cantilevers in such a position that the center of the channel comes as close as desirable to the edge of the mantle plate. This forms an octagonal ring of heavy channels which also reinforce powerfully the inner ends of the cantilevers and make it impossible for them to fail by buckling.

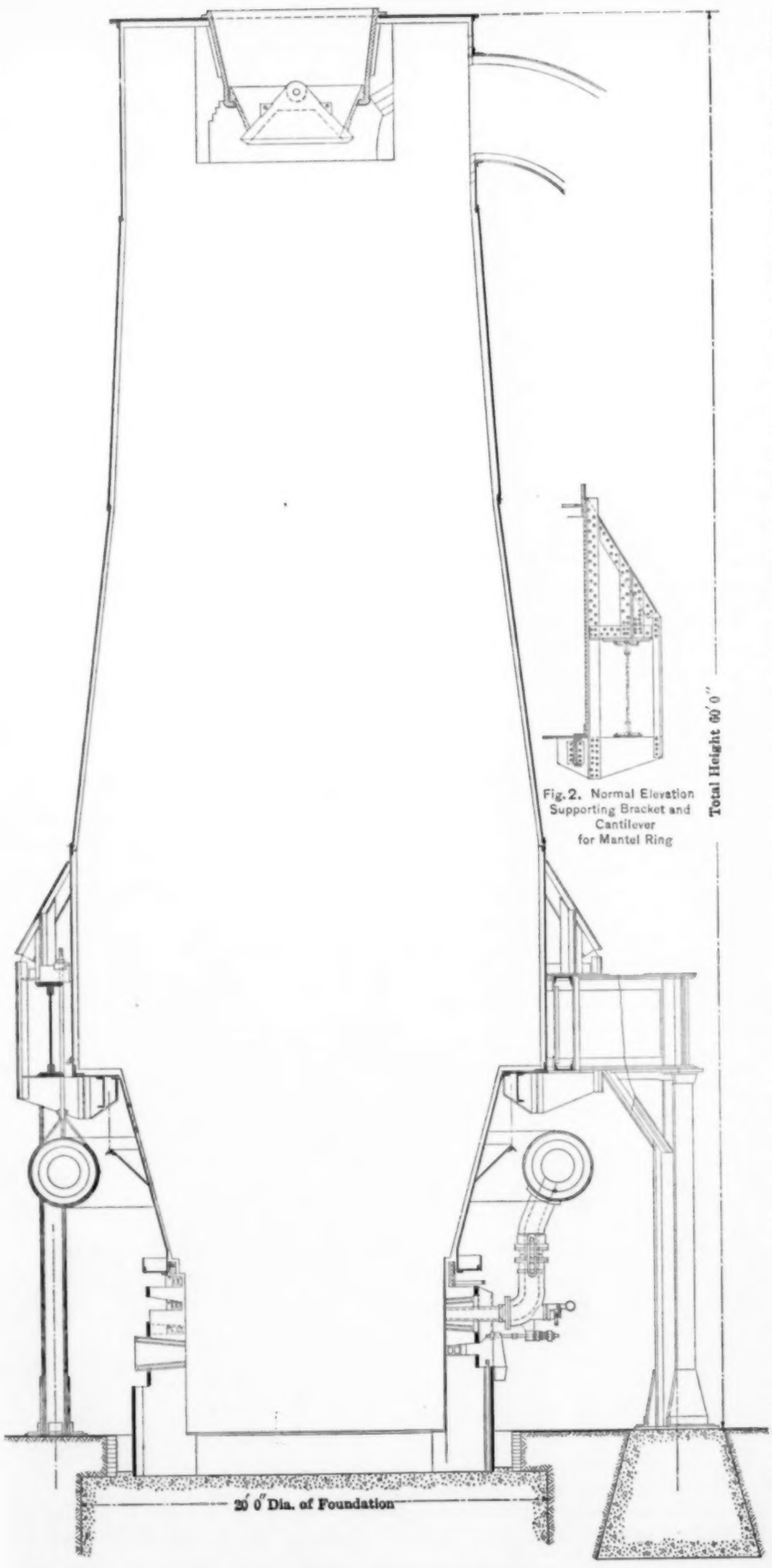


Fig. 2. Normal Elevation Supporting Bracket and Cantilever for Mantel Ring

FIG. 3—BLAST FURNACE DESIGN.

The general construction is shown by Fig. 3. The section on the right hand side is taken through the center line of column and a tuyere and penstock are shown as if they lay in the same plane. As a matter of fact, they do not; the center lines of those tuyeres which come nearest to the columns pass a foot or two to the side of the columns and allow ample room for rodding the tuyeres. This section was made in this way to show the minimum of room around the furnace at any point. The left-hand section is on a plane at right angles to the girder, and while the column in that view looks comparatively close to the furnace, it is, of course, in reality at the distance shown on the right-hand side.

It will be seen that four independent piers of concrete were provided and that these set back at a great distance from the foundation of the hearth of the furnace proper. These piers are at such a distance from the foundation of the hearth and so entirely separated therefrom that it seems impossible there should ever be any transmission of the expansion of the hearth through the soft dirt between the two, which could force the piers out of position. Therefore, the columns should remain as built indefinitely.

It will be noticed that brackets were introduced between the top of the column and the bottom of the girder on each corner to prevent any possibility of the columns failing by leaning all in the same direction circumferentially. Across the corners of the main girders channels were riveted at top and bottom to form diagonal braces. These were latticed together vertically for greater strength, as shown in Fig. 4, which shows the structural work without the shell. The girders were so located that the inner edge of their flanges was 4 inches from the shell at the closest point, and the corner braces were put 7 inches from the shell at the closest point, thus leaving plenty of access to the shell for anything that may be necessary, even behind the girders.

The brackets are not riveted to the girders either at top or bottom. This is for the reason that if the bottom ring of the shell should give way in any manner and carry the brackets out, then if the latter were riveted to the girder this would put a bend in the top or compression flanges of the girders and might induce their failure. The girders and brackets not being riveted together, opportunity is provided for the bracket to slide on the girder and leave the latter undeformed under any possible condition. In addition the bottom

ring of the shell was made very strong to provide against this contingency.

The inward thrust at the top of the brackets comes on the seam uniting the bottom and second shell plates and throws this into compression. The proportions of the bracket are such that the inward reaction from each one is relatively slight and the probabilities are that the sheets alone would be able to resist it without deformation, but in order to leave no doubt whatever on this score, a heavy 6-inch angle was run entirely around inside the shell just at the bottom edge of the second sheet in such a position as to receive the full thrust from the brackets.

This being the first time this construction had ever been used, it was not considered desirable to leave undone anything that could contribute to additional safety or provide against possibility of failure in unlikely ways. The probabilities are that some of these extra provisions for strength could be left off without detriment, but it was not considered desirable to do so in this initial installation.

In regard to the strength of the girders, they were designed to be safe with a low unit-stress, assuming that the weight of the shell, top rigging and top house; lining, back lining, bustle pipe and the entire charge from the hearth to to the stock line were supported on them. This last condition is most unlikely, but it is conceivable that the furnace might become so badly scaffolded just above the tuyeres that the weight of the whole charge would come onto the mantle and so onto the structural work. We, therefore, provided against this contingency in the design.

The general appearance of the furnace in operation is well shown by the photograph, Fig. 1. Two men stood shoulder to shoulder as nearly in line as they could be placed between the wicket on the penstock and the nearest column, in order to show the amount of room available. In addition to this, as above stated, this tuyere is not in line radially with this column so that the access to the tuyeres is even more unrestricted than would be indicated by the photograph. This could have been made even better than it is except that the hot-blast main was so located as to prevent placing the columns four-square with the line of the tapping hole, which would have been better in several respects, but we did not desire to disturb the hot-blast main and shifted the columns a foot or two to the left to miss it. It will be seen that the columns are bricked up to a height of 6 feet to prevent any possibility of damage to them by fire. We considered also making provision to keep them filled with waste water for several feet up, but this was not considered necessary. The brick-work surrounding them is hard fire-brick laid in cement and almost indestructible.

The accessibility of the furnace for work of any kind is remarkable and I do not think that anyone who had worked around a furnace of this design would ever desire to return to the old type of construction.

It will be noticed in Fig. 3 that the outside wall of the ditch is merely 4½ inches of brick. We had some trouble with the cinder cooler on one occasion since the furnace was blown in and got quite a little iron into the ditch beneath it. It ran around the furnace a distance of 7 or 8 feet. This would have been sufficient to tie itself in behind one or more columns with the old construction and would have been very difficult to get out. As it was, we simply tore down the 4½-inch wall from the outside of the ditch, pulled the "chunk" away from the hearth-jacket, out of the ditch, in one piece and replaced the 4½-inch wall. This accessibility is also a great advantage in working at water pipes, and, especially in following these from the cocks on the circle pipe to the cooling member that they supply.

The very short and direct connection from the bustle pipe to the tuyeres is shown both by Fig. 2 and by the photograph. In fact, the bustle pipe is almost too close to the bosh wall for greatest convenience. It is obvious that there is ample room to increase its circle and provide more room if it were ever desired to do so.

Objection will probably be made to this construction on the ground of cost, but the great saving in real cost over the standard construction is one of the features which pleased us most. The first cost of the four-column construction was less than $2,000 in excess of that of the standard construction, but of this saving about $1,000 would have been wiped out by the cost of work on the bustle pipe had we adopted the old construction for the following reason.

In order to have gotten the furnace lines desired with the standard construction we would have had either to provide a new bustle pipe complete or cut the present one down, cut it in two in six places and insert rings to increase its diameter and reline it complete, which could scarcely have been done for a thousand dollars. The actual money cost was, therefore, a few hundred dollars greater for the four-column construction than for the standard, but we have to consider also the element of time.

Owing to the location of the foundations for the new columns, one of these was put in before the old furnace was blown out. A second one could have been had we known

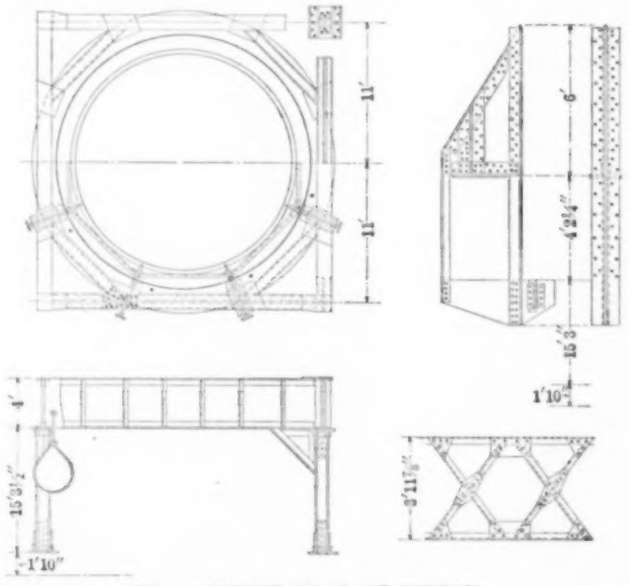


FIG. 4—SUPPORT FOR BLAST FURNACE

more accurately the location of the waste water sewer, but this and the two front ones were actually put in immediately after the furnace blew out and they were done before the work of tearing down the old furnace had progressed very far. Of course, if the standard construction had been employed the old columns would have had to be removed and the whole foundation exposed before the new foundation could be added. As it was, not only the foundations were built but the structural work for the new furnace was erected by the time the bosh and the upper part of the lining of the old furnace had been torn out. We estimate a saving of from two to three weeks in time on this account alone.

When the steel bosh jacket is used with the ordinary type of furnace it has necessarily to be fitted up and riveted together in several sections inside the columns, and, in fact, it is commonly attached to the edge of the mantle ring as it is put together with the necessity of a great deal of fitting of the vertical seams. In the present instance the bosh jacket was built entirely independent of the furnace and when the construction had advanced far enough to receive it, it was simply shoved in through the columns, hoisted up to place and riveted fast, the entire job taking only about two days as against two or three weeks that would have been required had it been built up in place in the customary way.*

We consider that we made easily a saving of five weeks on these two accounts alone. The loss of profits, overhead

*A paper read at the Cleveland meeting of the American Institute of Mining Engineers.

charges, etc., at such a plant can not be estimated at less than $500 a day, and this saving of thirty-five days, therefore, represents a saving of $17,500, or deducting $1,000 for the excess cost over the standard construction, a net saving by the use of this construction of $16,500.

It is customary to regard charcoal furnaces as insignificant in size, but this furnace is 60 feet high and of a size that would make from 200 to 300 tons per day with moderate driving on coke iron. Furnaces have such an enormous capacity for exerting destructive energy that the tendency in the minds familiar with them is to overestimate their actual weight. It is doubtful if the weight of a large coke furnace figured on the basis above described would exceed 2,000 tons, and there is no difficulty whatever in carrying a load of this amount with a construction of this kind.

It may be well to point out that this construction lends itself particularly well to the thin-lined type of furnace because the weight of the lining in such a furnace is an insignificant fraction of that of a standard thick lining, and because some outside structure is generally necessary for supporting the platforms, spray apparatus, etc., even if not the furnace top proper. This can all be done with great advantage from the girder frame if the type of construction here described be used.

It is well to point out also that if the cooling-plate construction of the hearth be used so as to form an adequate support for a thin lining in the zone immediately above the bosh, then the high mantle, which results from that construction, may be directly supported on the girders about as shown in Fig. 1. Methods can also be devised without difficulty for supporting the lining of the thin zone with the steel bosh jacket construction by providing a narrow water-cooled false mantle at the bosh angle, but we did not consider this construction necessary for our conditions.

CONCLUSIONS.

1. A furnace designed on the plan described is not only feasible but a safe and substantial construction.

2. This construction is especially well adapted to the thin-lined, or partly thin-lined furnace.

3. Its convenience in operation is so much greater than that of the older type of furnace that there is no comparison from an operating point of view.

4. The time to be saved by the use of this construction, at least in rebuilding, is so great as to constitute a money saving of far greater extent than the slight excess cost of this construction over the standard.

Ashland, Wis.

Annual Tables of Constants.—The price of the second volume of the Annual Tables of Constants, Chemical, Physical and Technological, published by the International Commission, will be $6, unbound, to subscribers who subscribe before January 31st, 1913.

Roasting and Drying Furnaces.—The Ridge Roasting Furnace and Engineering Company, 62 London Wall, London, E. C., has been formed to take over the patents of Mr. H. M. Ridge for roasting, calcining and drying furnaces.

Identification of Tellurides.—In a study of the tellurides of Kalgoorlie, published in the September *Journal* of the Chamber of Mines of Western Australia, J. Allan Thomson gives the following tests of identification: The presence of tellurium may easily be detected by blow-pipe tests. When heated on charcoal in the oxidizing flame, all the gold, silver, lead and mercury tellurides quickly fuse and emit dense white fumes of characteristic odor. They coat the charcoal with white TeO_2. When the bead is touched with the reducing flame it imparts to it a bright bluish green color. When heated in a closed tube the tellurides again form white TeO_2. This fuses on further heating to a liquid which is yellow when hot and white when cold. Sometimes a black sublimate of metallic tellurium is obtained. A simple wet test is to heat a fragment of the mineral on a porcelain plate and allow a few drops of sulphuric acid to flow over it.

Recent Progress in Electrolytic Process for Zinc.

Dr. **Victor Engelhardt,** the well-known chief engineer of the electrochemical department of the Siemens & Halske Company, delivered a lecture on electrolytic zinc processes at the recent first general meeting of the Gesellschaft Deutscher Metallhütten und Bergleute. Although Dr. Engelhardt is lecturing on electric furnaces at the new Institute of Technology in Breslau, he is more particularly familiar with electrolytic practice from large-scale work. The following is an abstract from his interesting paper:

The world's production of zinc, as taken from *Mineral Industry*, amounted to 815,097 metric tons in 1910, of which probably not more than 10,000 to 15,000 or 1.2 to 2 per cent were used as a high-grade metal of special purity. Zinc of 99.98 per cent purity is not much in demand, except for laboratory use and for making special pure brasses for use in cold drawing and pressing work such as are needed for cartridges, etc. This fact has held back the development of electrolytic zinc processes, especially as three considerable technical difficulties had to be overcome, viz., the difficulty of the design of suitable apparatus, the high-power consumption per unit of metal, and the fact that the zinc is liable to be deposited in spongy form.

Since there is little commercial use for high-grade electrolytic zinc at a higher price than ordinary zinc commands, the electrolytic process must be able to compete with the present marketable product. This, the author points out, is now possible under certain conditions.

He first reviews the older work in this line by briefly characterizing the main types of different processes which have been tried or suggested, without going into details of the enormous mass of patent literature.

I. Refining.

(a) *Anodes without precious metal.*—The mere refining of commercial zinc, analogous to copper refining, is economically absurd.

(b) *Anodes with precious metals.*—The refining of the ZnAg alloy, obtained from the desilverization of lead, with up to 10 per cent Ag, did not prove cheap enough and was apparently abandoned before the technical details could have been worked out.

II. Direct Processes.

(a) *With soluble anodes containing zinc.*—In order to utilize the energy due to the solution of the anode a great many attempts have been made since 1880 to prepare anodes containing various zinc compounds, mixed with coke or coal powder with and without pressure, with various binding materials, etc. They all must be recorded as failures as was the case with the analogous Marchese process in which it was tried to use copper ores or intermediate copper smelter products as anodes for direct production of copper.

(b) *With soluble anodes free from zinc.*—The patents of Cassel and Kjellin of 1892 started a series of equally unsuccessful experiments with diaphragm cells and anodes of iron in ferrous-sulphate solution or of lead in zinc chloride. Iron will soon contaminate the cathode electrolyte, and other trials gave no better results.

(c) *With non-soluble anodes and utilization of the anode energy.*—In two processes of Siemens & Halske, of 1886 and 1896, an attempt was made to use an electrolyte which would leach the sulfide or oxide ore and which would then be passed through an electrolytic cell where the metal would be deposited on the cathode, while the solution was regenerated at the anode. Both processes are merely of historical interest to-day.

The first process is represented by the two equations:

$$ZnS + Fe_2(SO_4)_3 + H_2SO_4 = ZnSO_4 + 2FeSO_4 + H_2SO_4 + S$$
$$ZnSO_4 + 2FeSO_4 + H_2SO_4 = Zn + Fe_2(SO_4)_3 + H_2SO_4.$$

The second one by:

$$ZnO + Al_2(SO_4)_3 = ZnSO_4 + Al_2O(SO_4)_2$$
$$ZnSO_4 + Al_2O(SO_4)_2 = Zn + Al_2(SO_4)_3 + O.$$

The basic aluminium sulfate was, however, partly decom-

posed during the leaching process and an integral part of the electrolyte was thereby lost.

(d) *With insoluble anodes and without utilization of the anodic energy.*—Processes of this group are the only ones which have reached the commercial stage. A typical example of $ZnCl_2$ electrolysis is the Hoepfner process, a typical example of $ZnSO_4$ electrolysis the Siemens-Halske process. The plants installed by Hoepfner in Germany, England and Austria are no longer in operation.

Hoepfner started from a cheap raw material, pyrite residues with about 10 per cent Zn, mostly as ZnS, which had to be subjected to a chloridizing roasting with subsequent leaching, freezing out of the Na_2SO_4, oxidation with hypochlorite of lime and precipitation, first by carbonate of lime, then by zinc dust. The purified solution was electrolyzed in a diaphragm cell with carbon anodes, and rotating cathodes of zinc or iron. The zinc produced by this process was of good quality, but the complexity of operation and apparatus and the necessity of collecting several by-products which were hitherto foreign to metallurgical plants and for which a market had to be found were serious objections.

The sulfate electrolyte affords simpler conditions in many respects. One point requiring the most careful attention in both cases is to avoid the formation of spongy metal. The cathodic zinc deposit cathode is not smooth enough for immediate rolling. The trade demands for alloying purposes small and easily detachable units. The electrolytic deposit is therefore molten and cast into forms of the customary shape. But when this is done, spongy metal oxidizes and is completely lost.

This problem is the most vital point of the whole process and decides on success or failure. The deposition of the purest possible zinc is therefore absolutely necessary. This is better attained in the Siemens-Halske sulfate process since the latter dispenses with diaphragms and rotating electrodes. The solution is purified in the same way as by Hoepfner, without requiring the removal of sodium sulfate. For economic reasons the accumulation of free sulfuric acid by reaction at the anode is carried on as far as the quality of the metal will allow. If it becomes too high, the danger of impurities in the cathode and of formation of spongy metal becomes imminent.

Lead Peroxide and Manganese Peroxide Anodes

The latest progress made by the Siemens-Halske Company relates to the manufacture of suitable anodes. Acheson graphite, the best anode for electrolysis of chlorides of alkalies and of zinc chloride, is corroded by sulfuric acid, platinum is too expensive and partly soluble, and the coating of PbO_2 formed on lead electrodes is not sufficiently coherent to prevent formation and dissolving of lead sulfate.

The invention of Dr. Ferchland, offered to the Siemens & Halske Company seven years ago, concerning the electrolytic formation of PbO_2 electrodes has been improved and perfected and is now in commercial use. PbO_2 is precipitated on anodes of carbon tubes (an addition of colloids permitting to produce a smooth deposit) and the carbon bored out afterward. Several of these lead peroxide tubes are held and connected together in parallel by a lead casting.

These anodes have been used in a small plant in Lipine, Silesia, Germany, where roasted upper Silesian blende is treated and smooth and thick plates of the following purity are produced.

	From Silesian Blende.			From Refractory Ores.
Pb	0.019	0.028	0.013	0.014
Fe	0.015	0.017	0.003	0.018
Mn, As, etc.	—	—	—	trace
Zn (difference)	99.966	99.955	99.984	99.968

The ampere-hour efficiency was 80 per cent at 3.8 volts per cell. The specific power consumption was, therefore, not quite 4 kw-hours per kilogram of zinc. The loss in melting was 3 per cent. The ductility of the zinc effected a 10 per cent production in the cost of rolling.

Whereas in this case the cost of the anodes ran up to 70 marks per ton of metal ($16 per 2000 lb.), the company succeeded quite recently, through the efforts of Dr. Max Huth, to reduce the anode cost to one-seventh. He tried to prepare anodes in the shape of plates and is now able to produce them from manganese peroxide, held in a carbon contact piece. The life of these anodes in commercial practice is estimated as about one year. Details of their manufacture are not revealed.

The power consumption has been reduced to 3.4 kw-hours per kilogram Zn, while chloride electrolysis requires 4.2 kw-hours for continuous operation.

Large experimental plants have been erected on this basis in England and in the United States, while the erection of a big commercial plant is projected.

The leaching of the ores which was done in Lipine in open stirring banks is carried out in England and the United States by a special process of Dr. Isherwood, who uses an insufficient amount of sulfuric acid under pressure and thus obtains purer solutions from the start.

We omit Dr. Engelhardt's calculation of the operating costs as differing too widely under varying conditions. It will be sufficient to say that cheap ore, preferably such ores as will be less suitable for reduction in the muffle, and cheap water power are the main requirements for the new process. At marks 222 per ton of zinc in the ore, the power would have to cost 2.5 pfennigs or 0.6 cent per kw-hour in order to just cover the manufacturing cost with the market price.

The interesting discussion of the paper by Dr. Hans Goldschmidt revealed the fact, that the low loss in melting the cathodes results from dipping the cathodes into molten zinc and excluding the air to the greatest possible extent.

The complete paper is published in *Metall und Erz*, Vol. 10, p. 60-72, 1912.

British Salt Trade.

An increase in the number of salt works on the Cheshire side of the Ship Canal is expected as a consequence of the establishment of the right to pump brine; and at Lymm the existence of very large salt deposits has been ascertained. The Castner-Kellner Alkali Works, at Runcorn, draw brine from the Marbury pipe, and extensive operations are expected to be undertaken shortly on the Heatley estate, which has a long frontage on the canal. The result of borings made near Heatley Station is asserted to show the existence of a thick bed of rock salt on the estate.

British Engineering Imports and Exports.

The returns issued by the Board of Trade for the nine months ended on Sept. 30 show considerable increases in the value of both imports and exports of engineering material—imports of ships excepted—as compared with the corresponding period of last year. Imports of iron and steel, including manufactures, totaled £9,232,320, an increase of £1,031,046, and exports were £34,549,271, an increase of £2,697,070. In other metals, including manufactures, imports reached £22,230,943, an increase of £1,500,064, while exports touched £8,684,345, an increase of £659,384. Imports of electrical goods went up to £1,036,376, increasing £23,733, and exports figured at £3,198,770, a rise of £1,207,918. Imports of machinery amounted to £4,995,829, an improvement of £584,181, and exports moved to £24,056,385, a rise of £1,520,443. For new ships the imports were £25,308, a decline of £35,608, but exports rose to £4,433,042, an improvement of £393,560.

Taking the month of September by itself, imports and exports of iron and steel showed, respectively, increases of £338,493 and £1,405,816; in other metals imports fell £233,210 and exports rose £232,717; imports and exports of machinery rose £62,033 and £756,186, respectively; in electrical goods imports dropped £10,859, but exports were £277,024 better; imports of new ships were £3,719 lower, and exports improved £384,792.

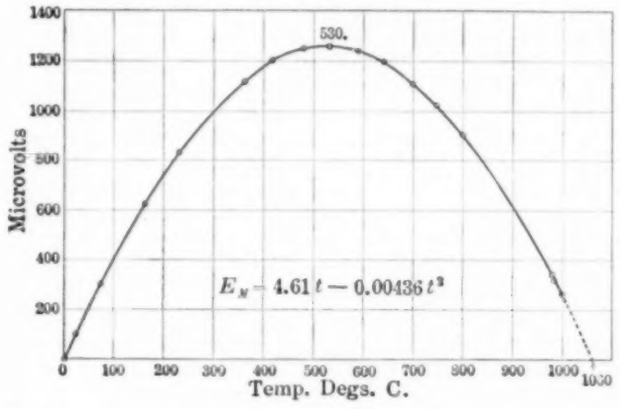
Tungsten and Molybdenum—Their Thermal Emf.

By Edwin F. Northrup, Ph.D.

The writer suggested at a recent meeting of the Philadelphia local branch of the American Institute of Electrical Engineers, that the possibilities for further developments are greater in thermocouple pyrometry than they are in electrical resistance pyrometry. He remarked that possibly tungsten and molybdenum might be used at high temperatures for a thermocouple and that although these metals oxidize at high temperatures, it might be possible to avoid oxidation by the use of some kind of protecting covering.

In reply to these statements it was remarked by a manufacturer of pyrometers that the writer's suggestion seemed to be an excellent one, with one exception, namely, that between tungsten and molybdenum there exists *no* thermal emf. The speaker said he knew because he had experimentally tested the truth of his statement.

The writer was silenced because he had not at the time tested the property in question of these two metals. He was not,



E. M. F.—TEMPERATURE CURVE OF TUNGSTEN-MOLYBDENUM THERMOCOUPLE.

however, convinced and later through the kindness of Dr. W. R. Whitney, of the Research Laboratory, of the General Electric Company, he was able to obtain a wire of tungsten and a wire of molybdenum, each about No. 20 B. & S. gauge. With the furnace at his disposal he was able to determine the curve relating emf to temperature in the range 0 deg. C. to 1000 deg. C. The curve obtained is given in the accompanying diagram.

The emf's were measured with a Leeds and Northrup potentiometer and the temperature was measured by measuring the emf developed by a platinum, platinum plus 10 per cent rhodium thermocouple. This thermocouple was accompanied by a certificate from the Bureau of Standards.

The following points may be mentioned:

The equation,

$E = 4.61\,t - 0.00436\,t^2$ microvolts fits the curve in the range from 0 to 1000 deg. C. with an error of less than 4 per cent.

When the cold junction is at 0 deg. C. the emf is a maximum at 530 deg. C. and is 0 at 1060 deg. C., which, within the limits of error of the experiment, is the melting point of gold (1062 deg. C.). The current in this range flows from tungsten to molybdenum through the hot junction. The thermal e.m.f. is sufficiently high at 300 deg. C. or at 750 deg. C. to be measured on the potentiometer used within 0.2 of 1 per cent.

If the law of the thermal emf as given by the equation continues to hold to a temperature of 2200 deg. C. the thermal emf would be at this temperature, when the cold junction is at 0 deg. C., 10,960 microvolts or about 11 millivolts—an easily measured emf. The molybdenum would then, of course, be positive to tungsten at the hot junction.

It is very desirable that many samples of tungsten and molybdenum be tested in the above manner. If they all have a neutral point at the same temperature, namely, at 1060 deg. C., then a thermocouple of these metals would serve in a very convenient way to fix this temperature. A couple or a resistance thermometer to be tested would be put in the same electric oven with the tungsten molybdenum couple and the temperature raised until the latter showed zero emf. The temperature would then be 1060 deg. C.

The writer does not think that there is no hope of finding a protecting case for the couple at 2000 deg. C. or more. At 100 deg. C. the oxidation is negligible and for laboratory work it could be prevented in most cases for higher temperatures by employing a non-oxidizing gas.

Palmer Physical Laboratory,
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Some Present Pickling Methods.

By Oliver W. Storey.

In the hot working of iron, steel and cast iron, the unavoidable formation of a scale makes the subsequent operation of pickling necessary, especially in the various galvanizing, plating and enameling processes. This scale consists essentially of the magnetic oxide of iron, which is resistant to corrosive action.

Ordinary mill scale, as found on hot-worked materials, is present in various thicknesses. On black sheets it is present as a thin coating, while on heavy rolled shapes it is much thicker, often being over 1/32" in thickness. The coating especially when heavy is usually porous and brittle, while more flexible and continuous when thin.

The resistance of a certain quality of iron oxide to corrosive action is the basis of the protective coatings of the Bauer-Barff and Wells processes. By these methods a thin continuous coating of the magnetic oxide is produced on the surface of the iron and the article is rendered immune to corrosion as long as the continuity of the coating is not broken. Since the magnetic oxide is electronegative to iron by nearly two volts, the damaging of the surface will start a rapid electrochemical corrosion of the iron base.

For ease in removing scale by pickling a continuous coating of the magnetic oxide is undesirable since it is insoluble in the pickling acid and prevents the action on the underlying iron. It is well known that the principal function of the pickling acid is not dissolving the scale but the dissolving of the underlying iron sufficiently to loosen the scale. Scale formed under ordinary hot working conditions is porous and is usually easily removed.

If all the scale found on iron and steel were pure magnetic oxide, the problem of pickling would not be as troublesome as it is at present. Not only does the thickness of the scale vary, but its composition varies owing to impurities. Ordinary black sheets do not always present a smooth surface but often are very rough. It will be found that cinder, slag and scale contained in these rough places cause trouble in pickling. Since a much longer time is required to remove the scale from these rough spots the rest of the surface will be overpickled and the cleaned iron will present an uneven surface. Similar troubles are found in the pickling of iron pipe. Forged material is especially difficult to pickle owing to the cinder and scale that is driven into the iron.

Acids Used for Pickling.

The acids usually used for pickling are sulphuric, hydrochloric and hydrofluoric. The last is frequently used on castings to dissolve any adhering sand that may be in a position where it cannot be easily removed by tumbling or sand blasting. Sulphuric acid is the one almost universally used for pickling purposes. This is owing to its cheapness and ease of transportation in large quantities by tank cars. Sixty deg. and 66 deg. Be. acid is worth from 80c. to 90c. a hundred f.o.b. plant in most industrial districts, this price holding for a brimstone acid containing a minimum of arsenic. The sulphuric acid must have high purity since certain impurities will cut down the pickling power. Arsenic especially is most undesirable as an exceedingly small quantity is harmful.

Prof. C. F. Burgess was among the first to show the quantitative relation between the arsenic content of sulphuric acid to its pickling power and to give an explanation of this phenomenon.[1] It had been known in general for over sixty years that the presence of arsenic in sulphuric acid was detrimental when used for pickling purposes, but no definite work had been done or had any explanation been offered.

Dr. O. P. Watts has elaborated on this work and the influence of various materials on the rate of corrosion of iron has been investigated in the Chemical Engineering Laboratories of the University of Wisconsin and some interesting results obtained.[2] These results show that arsenic is an effective retarder of corrosion and the same is true of tin. Lead, which is soluble to a slight extent in sulphuric acid, is also a retardent. While certain materials are more or less effective in retarding corrosion, others may cause accelerated action.

It would appear that a mixture of acids, such as sulphuric and hydrochloric, ought to cause an accelerated rate of corrosion, but the results show a high rate of retardation.

These experiments indicate that the acids used for pickling purposes must be free from those materials that retard corrosion to be able to secure a maximum pickling efficiency. A small amount of these retarding materials present in the acid will often cut the capacity of the pickling plant in two and perhaps double the acid cost. A study of the action of sulphites and of selenium on the corrosion rate would be of importance, since these are also usually present in varying quantities in commercial acid. In fact, the whole question of the influence of impurities as to their influence on efficiency of pickling is worthy of further investigation.

Where large quantities of the acid are used it is bought in carload lots and stored in large iron containers. If the acid has to be transported and stored in glass carboys it adds materially to the cost, owing to the large amount of handling during transportation, higher freight charges owing to freight classification, breakage of carboys and the danger in handling glass containers of acid.

The layout of a pickling plant depends on several factors, these being principally the character of the material to be pickled, capacity required, and the relation of the pickling process to the rest of the plant.

The character of material is of utmost importance as the various grades of iron, steel, and cast iron corrode at widely varying rates, the rate depending upon the kind of acid and the purity of the iron.[3] In general, the lower the carbon content of the iron the lower the corrosion rate in materials subjected to the same heat treatment.

Pickling of Black Steel Sheets.

Probably the two materials that are most frequently pickled are black steel sheets and wrought iron and steel pipe, including both water pipe and conduit. Steel sheets are usually covered with a thin scale that can be easily removed, while the scale usually found on pipe is more difficult to remove owing to its weight. The methods used for pickling these materials will be taken up in detail.

To operate a pickling plant successfully requires a large supply of hot and cold water. A large amount of water is needed for washing after pickling to remove all traces of acids and metallic salts.

The pickling of black sheets is usually done with the so-called pickling machines. Such machines are now on the market capable of handling the material rapidly and economically, a typical one in general use being the Mesta pickling machine.[4] It consists essentially of a vertical plunger working in a cylinder, with three arms 120 deg. apart at the top of the plunger which is worked by steam or compressed air. Two vats are required with this type of machine; one acid and the other water. While one crate of sheets on the first arm is pickling in the first vat, the second crate on the second arm is being washed in water, while the third is being unloaded or reloaded. If a third vat is necessary the machine can be built with four arms.

The vats are constructed to the dimensions required by the material to be pickled. The crates are often made of wood but more often of some acid-resisting alloy. Where wood is employed nails or bolts of copper are necessary. The sheets are rested on edge in this crate, which is usually large enough to hold from 1500 to 2000 lb. of the material.

When sulphuric acid is used the strength of the solution usually varies from 3 to 8 per cent, and it is usually kept as near boiling as possible by injecting live steam into the vat. The high temperature has a remarkable effect on the rapidity and efficiency of the action. The sheets are forced apart to secure complete pickling by violently agitating the acid solution. With suitable agitation and separation of the sheets, this process may be completed in six to 10 minutes with a 6 per cent pickle. When a weak pickle, such as a 3 per cent solution and a temperature of about 180 deg. Fahr. is used, the sheets usually require about 30 minutes for complete removal of scale.

After being pickled they are transferred to the washing tank where the acid and ferrous salts are removed as completely as possible by copious supplies of fresh water. If the wash water is hot the sheets will dry quickly when brought into the air with the formation of but a negligible quantity of iron oxide. If the sheets are not for immediate use and are to be stored or shipped they are dipped in a lime or soda solution to kill any acid that may be present and prevent the formation of rust.

This method of pickling will remove all of the scale, but owing to the short period in the acid will not remove any cinder that may have been rolled into the surface of the sheet. If the sheet remains in the acid a greater length of time, the acid may attack enough of the iron to precipitate out a black deposit of carbon or some form of combined carbon that may cause trouble in later processes. Therefore, the sheets stay in the acid the minimum length of time required to remove the ordinary mill scale. About 140 lb. of 66-deg. acid is required per ton of sheets, though this of course varies with the thickness and other characteristics of the material.

Pickling of Pipe.

In the pickling of steel and wrought-iron pipe a different method is in use. For ordinary galvanizing purposes only the exterior of a pipe needs to be entirely free of scale in contrast with pipe for conduit purposes, where both interior and exterior have to be cleaned.

Vats are made the requisite length, 4 ft. to 6 ft. wide, and from 2 ft. to 3 ft. deep. The acid bath, the strength of which varies from 3 to 10 per cent of sulphuric acid, is heated by means of injected steam. The pipes are held in two acid-proof chains and at short intervals of time they are tumbled over each other by working these chains.[5] This operation is repeated several times during the pickling period. The tumbling of the material is necessary for several reasons. It circulates the bath, especially in the interior of the pipe and it helps loosen some of the tougher scale of the exterior by abrasion and it also washes away the detached scale. When the exterior is sufficiently clear of scale the pipes are washed in water, as with sheets, and if they are to be hot galvanized, they are dipped into a hydrochloric acid solution. Upon removal the iron chloride formed is allowed to dry and acts as a flux in the galvanizing bath.

The pickling of pipe for conduit purposes presents a different problem. There are two methods in use for giving conduit a protective coating, enameling and galvanizing. Galvanizing may be hot, wet or electro, and dry or sherardizing. The same general method of pickling with sulphuric acid is used. Conduit pipe is 10 ft. long and must be thoroughly cleaned on the interior and exterior. Any scale remaining on the inside of conduit pipe will be a sufficient cause for its rejection by the Board of Underwriters, whose requirements are rigid.

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[1] Tr. A. E. S. **8**, 165,195.
[2] O. P. Watts, Tr. A. E. S. **21**, 337, 1912.
[3] Burgess and Engle, Tr. A. E. S. **9**, 199, 1906.
[4] Metallurgical and Chemical Engineering, Vol. **8**, No. 10, p. 598.
[5] Buchert, Stahl und Eisen, **32**, 1487-9.

Before entering on the description of methods used for pickling conduit pipe it will be necessary to describe the scale found on the interior and exterior of the pipe. This will necessarily require a brief description of the methods of manufacture.

Conduit pipe is butt welded. The skelp is heated in a furnace whose bottom is usually lined with silica. At the temperature of the furnace the acid silica and basic iron oxide unite to form one of the easily fusible silicates of iron. When the skelp is withdrawn from the furnace it is drawn into the forming die so that the bottom of the skelp will come in the inside of the pipe. The silicate slag will therefore be found on the interior of the conduit. This silicate then runs to the bottom of the conduit and solidifies as a strip of hard glassy slag that adheres quite firmly to the iron. It has been suggested that the upper part of the skelp be turned in, but owing to the rapidity with which the silicate slag ruins the dies this is never practiced. This silicate slag is the cause of the trouble that is encountered in pickling pipe.

Since the interior of conduit pipe must be free from scale it presents difficulties that are not present when ordinary pipe is treated. The acid in the interior must be kept in circulation so as to have the rate of pickling as fast on the interior as on the exterior. Various methods have been tried, of which the more successful may be described.

Pickling on end is a natural method to suggest, the material being hung on racks and lowered into the acid vats. The hydrogen liberated on the interior of the pipe and rising to the surface creates a circulation of the acid bath. This method is effectual but it is open to several objections. The hanging of the material on the racks requires an extra operation and the same is true in taking the material down. The racks occupy a large space for a given number of pipe and the space required for the pickling plant is large. Large hoists are required for the lifting of material over a distance of at least 11 ft. Should the drainage sewers be down at the ordinary distance of about 6 ft. and it is required that the waste liquor run into them, it will be seen that the tanks will have to be elevated some distance to procure proper drainage. If any break should occur in the hoisting apparatus, a fall of 11 ft. to 12 ft. of the heavily loaded racks would probably be fatal to the pickling tank. The tanks would not be adapted for the pickling of other classes of materials.

The other methods of pickling consist of treating the conduit in a horizontal position instead of vertical. In this way the layout of the plant will be simpler since the tanks will be from 2 ft. to 3 ft. deep, 4 ft. wide and 11 ft. long. The material is laid in a cradle arrangement, the couplings on the one end of the pipe causing them to be completely separated and allowing the entire surface to be subject to the acid attack. This method allows of large quantities of pipe to be pickled in one vat. The methods used for getting a good circulation of acid in horizontal tanks differ.

The intermittent method is one in which the circulation is secured in the following manner: At certain intervals of about every fifteen or twenty minutes the racks or cradles of pipe are lifted from the tanks so that the pipes are at an angle with the horizontal, allowing them to drain easily. By plunging the rack up and down in the acid several times the loose scale and dirt are removed from the interior and the pickling is again allowed to proceed. This method is especially satisfactory where a weak pickle is used.

Another method of securing circulation is to have the pipe lay in a rocking cradle working in the acid. This secures excellent circulation, but it is open to the objection that it requires machinery to be present in a pickle room and in the bath where deterioration is rapid. By introducing paddle wheels, propellers and plungers, into the vats, circulation has been secured, but none of the methods given seem to give entire satisfaction.

In the treatment of conduit, the time of pickling is judged by the interior appearance. The exterior may become free from scale in a short time, but the interior may still contain a large amount. The conduit must remain in the pickle until all of this scale is removed or until the iron surface or screw threads become visibly corroded. When this happens the pipe must be removed from the pickle to avoid being scrapped and the remaining scale must be sand blasted or otherwise removed from the interior.

Where the pipe contains the hard ridge of iron silicate, ordinary pickling and sand blasting will not entirely remove it, and the remainder is generally left in the interior of the pipe. Such a rigid scale is detrimental since it makes fishing difficult and is liable to cut the insulation of the fished wire.

If the pipe is to be used for cold galvanizing purposes it is washed with cold water after removing from the pickle. It may be dipped in cold dilute hydrochloric acid and then taken directly to the plating tank to prevent any oxide from being formed. If the pipe is to be sherardized, it is dipped into hot water to remove the acid and iron salts, then into a lime water and finally into a hot-water bath. Upon removing from the hot water the pipe dries quickly and a minimum of iron oxide is formed. This small amount of oxide is not detrimental, but, in fact, appears to give a brighter coating. If the pipe is to be enameled it is treated in the same manner as is the sherardized material.

Strength and Temperature of Pickle and Other Details.

The strength of the pickle varies a great deal, running from 3 to 8 per cent sulphuric acid. These various strengths have their advantages and disadvantages. When a 3 per cent solution is used a larger plant is required. This is offset by the various other advantages gained. When a 3 per cent solution, at a temperature of about 170 deg. Fahr., is used the rate of pickling is slow, requiring from three to twenty-four hours to pickle ordinary pipe. With this slow rate pipe will not be easily over-pickled if it should be accidentally left in the pickle too long. The slow rate of hydrogen liberation lessens the amount of finely divided acid thrown into the air and makes it easier upon the workmen and also upon the buildings and machinery. It is also possible to "kill" a low percentage bath until almost free from acid and this prevents any acid being run into the drains. With high-percentage acid baths it is customary to "kill" a bath to a certain percentage and then run it off as waste. The high-percentage bath is also harder upon the workingmen. With a low-percentage pickle the amount of acid used per ton of pipe is much less than with a high-percentage pickle, usually running below 80 lb. per ton.

The temperature of the pickle is also very important, since the higher the temperature of the bath the faster the pickling. For most purposes it is best to have a boiling bath because it not alone produces a bigger tonnage, but it also removes all grease from the article to be pickled. With a boiling pickle, however, large volumes of acidulated steam are given off, with attendant corrosion of machinery, buildings, and the bad effect upon workmen.

The pickle is run until the action becomes too slow, when more acid is added. When a solution becomes concentrated with ferrous sulphate, the pickle is "killed" and then is generally run off as waste. The concentration in ferrous sulphate when "killed" varies a great deal, standing from 12 to 25 per cent, depending upon the practice at the plant.

Few plants attempt to utilize the ferrous salts and sulphuric acid in the waste pickle, since no satisfactory method has been offered. Its utilization has been made subject of a large number of patents. One of the most recent is that of F. F. Farnham, who electrolyzes the solution and obtains iron and sulphuric acid.[8] Where utilization is practiced a common method is to neutralize the free acid by means of iron scrap, evaporating and crystallizing the iron salts, producing the copperas of commerce. This copperas has various uses, such as the making of various shades of red pigments, Indian red and Venetian red. Recent advocacy by agricultural experiment stations of this material as a weed killer has increased the outlet for it, but with all of the uses proposed, a general recovery from all spent liquors would undoubtedly flood the market.

[8] F. F. Farnham, Patent No. 1,006,836, Metallurgical and Chemical Engineering, 9/12/1911, p. 67 O.

In galvanizing and sherardizing plants, where the zinc sometimes has to be stripped from the iron, owing to defects and other causes, an old pickle is usually used for stripping the zinc and is found to work best. The potential of iron is below that of zinc and naturally the iron in the pickle as ferrous sulphate has a tendency to plate out and remove the zinc, though little acid is present.

Air hoists are generally used in pickling rooms owing to their simplicity, ease of operation and low cost of upkeep. Though compressed air as a source of power is costly, the other advantages gained by the use of compressed air counterbalance this factor.

Large and non-corrosive drains should be provided to take care of large amounts of water and killed acid. The best floors for pickling rooms are made of the iron scale that is deposited in the bottom of pickling tanks. This material is porous, is not attacked by acids, cheap and easily laid. Cement and concrete will quickly disintegrate and are therefore not available.

Another use found for the scale and sludge deposited in the bottom of the pickling vats is for the stopping of leaks in these vats.

By merely plastering this sludge into the leaky part the leak may be easily and effectually stopped.

This paper does not attempt to give all methods in use, but rather to describe what may be considered as general practice in pipe and sheet pickling at the present date. Pickling is a branch in the metallurgy of iron and steel that is open to a large amount of improvement. Mechanical treatment and cleaning of the materials has often been tried, but sulphuric acid treatment seems most satisfactory. Pickling plants are run more or less on hit-and-miss methods and the only improvements that have been made are in the mechanical end. The fault does not lie entirely with the chemical end of the industry for improvements may be made in the hot working of the metal so as to give a product of a kind that can be more easily pickled.

The ideal condition will be where the scale would be entirely soluble in some solvent while the iron would be insoluble. Since this is probably impossible, it would be well to obtain a condition where a minimum of scale is formed and in this way requiring but a short acid attack, resulting in minimum corrosion of the iron base.

Viewing the operation from a scientific standpoint the pickling process seems to be the application of "main force and awkwardness." The object is to present a clean iron surface, and this is done not by dissolving or otherwise eliminating the coating, but by dissolving away the iron surface itself. There is here an economic loss, not only in the mill scale and of the acid, but of the good iron which is taken away. It is difficult to predict in what direction the possibility of improvement lies; it may be in the discovery of some cheap solvent for the scale itself, in some electrolytic or other method of reducing the iron oxide, or perhaps in some mechanical or physical method.

Even though the remedy is not in sight the problem is of sufficient magnitude to warrant extended investigation.

Chemical Engineering Laboratory,
University of Wisconsin.

The **Pittsburgh Testing Laboratory** of Pittsburgh, Pa., announces that Mr. James Otis Handy, for 23 years chief chemist, has been appointed director of research and chemical engineering, and that Mr. Howard H. Craver, for 14 years assistant chief chemist, has been appointed chief chemist of their laboratories.

The **Old Freibergers in America** held a pleasant dinner meeting on December 20th in the Hofbrau Haus, Broadway and Thirtieth Street, New York City. All old students of the Freiberg Bergakademie, who have not yet received notices concerning such meetings are requested to send their address to Mr. C. L. Bryden, 1015 Myrtle Street, Scranton, Pa.

A Curious Manifestation of Electric Constriction.

By Edwin F. Northrup, Ph. D.

If a trough of mercury having the dimensions shown in Fig. 1 be provided, and if a piece of copper sheet of the shape shown in Fig. 2 be floated upon the surface of the mercury, then, when twelve volts from a large storage battery are applied to the ends of the mercury in the trough, the following phenomena are manifested: The copper pieces when placed at either end of the trough with its rounded end pointing toward the far end will move with a speed of about 80 centimeters

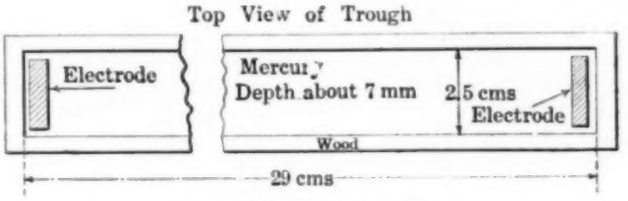


FIG. 1.—DIMENSIONS OF TROUGH.

per second the length of the trough. If the copper piece is held stationary the mercury will be greatly agitated at its pointed end.

These effects are to be thus explained: Copper has about sixty times the conductivity of mercury. The current stream lines are thus very much more dense at the pointed end of the copper piece than they are at the rounded end. The elementary mercury filaments by their mutual attraction produce a greater pressure at the pointed end than at the rounded end, hence the copper "boat" moves rapidly forward.

The writer is not unaware that practical uses may be made of this manifestation of the pressure forces in a liquid carrying a current (direct or alternating). He has designed, on paper, what appears to be an excellent ammeter, and other uses are thinkable. If in a tube containing molten metal there is fastened a piece of solid metal of high conductivity and having the shape of a plumb bob, then when current passes the fluid metal would move rapidly if the solid piece cannot move.

Very much has been written about the "pinch" phenomenon, but the writer wishes to call attention here to the fact that it was he who first thoroughly investigated this phenomenon experimentally and deduced the equations which express all the laws of the phenomenon for a conductor of circular cross-section. These experiments and laws are fully set forth in an article by the writer entitled "Some Newly Observed Manifestations of the Forces in the Interior of an Electric Conductor," *Physical Review*, Vol. XXIV, No. 6, June, 1907, pages 474-497.

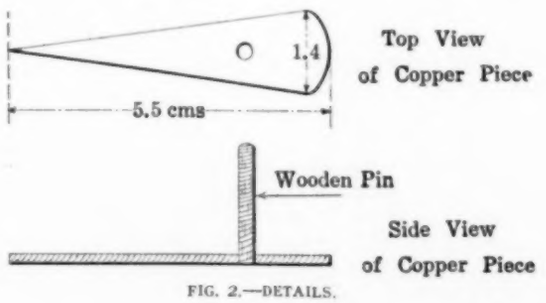


FIG. 2.—DETAILS.

In a paper by the writer entitled "A New Type of Ammeter for the Accurate Measurement of Alternating Currents Above 1000 Amperes," presented at the meeting of the American Electrochemical Society, May 17, 1909, the writer showed how the forces in question had been applied by him to the construction of an accurate type of ammeter for measuring large direct or alternating currents.

Palmer Physical Laboratory, Princeton, N. J.

The Western Metallurgical Field.

Eastern and Western Spelter Conditions.

The situation with regard to the mining of zinc ores and production of spelter has not greatly changed during the past year. The high price of spelter naturally has spurred the miner to greater activity. There has been an increase in ore tonnage both East and West, but not along the same lines. The Joplin increase is shown in the marketing of 7000 to 8000 tons of concentrates weekly where the 1911 output was but 5000 tons. The ore is being extracted as rapidly as possible and rushed to market.

The Western increase is not so much in larger weekly shipments but in very substantial additions to ore reserves awaiting extraction. This reflects quite clearly the difference in operating conditions between East and West. Joplin mine and mill equipment is comparatively cheap, and the machinery is readily salable at second hand. Under these conditions ore reserves are not essential. Furthermore, the product is high-grade and meets a sure and immediate market. The Western operator requires a more expensive equipment, usually unsalable when worn, and finds a much more irregular and restricted market for his lower-grade output. Therefore, ore must be in reserve before he may safely provide proper equipment. It is quite likely, however, that actual shipments from the West during the latter part of 1912 would have been larger but for shortage of cars.

It has become more certain during the year that a considerable portion of the Western zinc tonnage will come from scattered ore bodies of moderate size rather than from large deposits, and these smaller ore bodies are quite uniformly complex and difficult to treat. No large bodies of high-grade ore exist in America to compare with Broken Hill in Australia, say, where 5,000,000 tons of tailings still await treatment and where there are still millions of tons of unbroken ore in the mines.

The only deposit approaching this is that of the Butte and Superior Mine in Montana, where about 3,000,000 tons of 20 per cent zinc is said to be fairly in sight. There is a tendency among some mining men to assume that methods adopted by the owners of this property may be blindly followed by most others having complex ores awaiting treatment. This may easily prove dangerous ground to take.

The Butte and Superior ore is notably free from iron and copper, as complex ores go, so that concentration and flotation yield high-grade zinc concentrates not requiring separation. Even the adjoining mines in Butte so far as now opened do not show the same clean ore.

Cost of Milling at the Liberty Bell.

At the mill of the Liberty Bell Gold Mining Company, Telluride, Colo., recovery of gold and silver is made by amalgamation, concentration and cyanidation. Situated in a district noted for high freight rates, wages and cost of living, the cost of treating a low-grade ore by this process is remarkably low, and specially interesting to engineers having similar obstacles to overcome. The figures given in the right-hand column represent operating conditions in October, November and December, 1911, and are based on the treatment of 104,460 tons of ore.

LABOR.	Cents per ton.	SUPPLIES.	Cents per ton.
Superintendence	2.68	Pipe lines[1]	0.61
Heating	1.29	Bins[1]	0.85
Electric Plant	1.06	Buildings[1]	6.28
Lubricating	0.34	Electric Plant	1.11
Pumping Plant	2.12	Pumping Plant	1.98
Watchman	0.83	Fuel and Heating Plant	4.71
Examination and Tests.	0.68	Tools[1]	0.43
		Cyanide[1]	26.14
		Lime[1]	4.26
		Lead Salts	3.30
		Light & Power[2]	3.78
		Oil & Waste	0.91
		Assaying & Melting[1]	3.47
		Examination & Tests	0.27
		Miscellaneous	0.01
Total general mill labor	9.01	Total general mill supplies	58.11

[1]Indicates combined labor and supply.
[2]Power in this charge represents that used in pumping between departments.

Direct Charges to Several Departments.

LABOR.	Cents per ton.	SUPPLIES.	Cents per ton.
Crushing	5.31	Crushing	1.96
Stamping	9.35	Stamping	9.73
Regrinding	1.04	Regrinding	6.65
Settling & Agitation	1.50	Settling & Agitation	3.90
Filtering	3.72	Filtering	5.09
Concentrating	4.76	Concentrating	1.99
Amalgamation	4.26	Amalgamation	2.24
Precipitation	1.37	Precipitation	7.55
All Labor	40.32	All Supplies	97.22
All Supplies	97.22		
All Local Cost	137.54	or $1.3754 per ton ore treated.	

Kick's Law and Rock-Crushing Efficiency.

The use of Kick's law in computing the crushing efficiency of different machines has evoked considerable discussion, particularly on the Rand, where Mr. H. Stadler has been an advocate of this method. Recently some interesting work has been done at McGill University, in which Rittinger's law has been disproved and Kick's law adopted as more nearly in accord with the truth. The following extract is from a report issued by the University:

ROCK CRUSHING.—"A series of investigations have been carried on by a succession of fellows during several years on rock crushing, and the consumption of power has been very accurately measured for several standard types of crusher, working on different kinds of rock and crushing to different degrees of fineness. The result of these experiments is to finally disprove the 'law' of crushing originally enunciated by Rittinger and accepted by nearly all authorities since his day, and to show that the more recent theory advanced by Kick is either true or so nearly so that it affords a close working approximation to the truth.

"Kick's 'law' was originally stated in 1885 as a general proposition in mechanics, and it is only within the last few years that it has been applied to ore dressing first by Stadler in South Africa, and more recently by the McGill staff. But in terms of rock crushing it may be stated as follows: The power necessary to crush a given quantity of any given rock from any known size to any other known size, will be directly proportional to the reduction in volume of the particles—in other words have a ton of rock all in pieces, say, 1 in. in diameter, it will take almost three times as much power to crush them to pieces ½ in. in diameter as to pieces ¾ in. in diameter; or it will take twice as much power to crush from 1 in. to ¼ in. as from 1 in. to ½ in.

"The law as above stated is of course impractical, first, because it makes no allowance for the imperfections of the crushing machinery, or for the difference between one kind of crusher and another, and second, because it is not a practical possibility to feed a crusher with rock all broken to exactly the same size; but as Stadler has pointed out, if the law is theoretically true, it is possible to take any quantity of mixed rock, and by sizing it before crushing and weighing the different sizes, then crushing, say, half the lot in one machine and the remainder in another, and finally by again sizing and weighing

the products, it is possible to determine the relative useful work done by each machine, or in other words to determine the comparative efficiencies of different crushers.

"The McGill experiments were first directed to settling the question of the truth of the theory and, as stated above, the results of a very large series of experiments agree with the law to within the reasonable limits of error of experiment on so variable a material as broken rock.

"The next thing to be done was to compare the efficiency of a single crusher, say, a Gates breaker, over different parts of its range, *i.e.*, to determine whether it gave as high an efficiency when working from say, 4 in. to 1 in. as from 4 in. to 2 in. or from 2 in. to 1 in.; and similarly to study other crushers such as stamps, rolls, tube mills, etc., with a view to finding the most efficient range of each machine and the comparative efficiencies of the different machines.

"Obviously the amount of ground to be covered is enormous, especially as the experiments have to be carried out on a large scale yet with the utmost care to eliminate errors. Therefore, only a small part of the work has as yet been completed, but enough has been done to justify the preparation of a preliminary report which is now being prepared for publication, and it is confidently believed that it will soon be possible to state with a very considerable degree of certainty just what types of crusher are most suitable for particular degrees of crushing, and to state what output may be expected for any rock for which the confines have been determined."

Utah.

At a recent meeting of the Utah Society of Engineers, at Salt Lake City, Mr. H. D. Randall, of the General Electric Company, read a paper on the Hydro-electric Power Resources Tributary to Salt Lake City. He gave a list of the developed water-power plants, excluding a few of the smaller municipal systems, showing a total rated development of 66,850 kw. Of this quantity, Mr. Randall estimated that about 45,000 kw. is available for delivery in the tributary markets. As to the future possibilities, he estimated that 105,750 additional kilowatts could be developed, of which about 90,000 kw. would be always available.

The year 1912 closed without the discovery of any important new mining districts in Utah. Increased activity was noted, however, in all the old districts, with some progress in metallurgical work on ores from old or abandoned mines. The Mines Operating Company, which acquired the old Ontario at Park City last year, is reported to have completed its experimental work on the old low-grade ore, and has adopted a chlorination process. Cyanidation was first tried, and it was thought that the process would be successful, but further work indicated that it would not be best adapted to the general run of ore, and further experiments resulted in the decision to use a chloridizing roast, followed by leaching. Details of the process have not been made public, and probably will not be until the new mill is working satisfactorily.

The Utah Copper Company is again operating at full capacity, following the labor strike of last fall. On December 1, general manager Jackling issued a statement to the effect that the company was then mining 20,000 tons per day, and that substantially a full crew of men was at work. He also announced an increase of pay for pit men, track men and laborers of all classes, as well as for employees in the mechanical department. This applies to men working at Bingham, and is consistent with the increase announced a month earlier for men at the Garfield concentrating mills. The increase ranges from 20 to 25 cents per day, and will be effective during the period of relatively favorable prices in the copper market.

Dry Concentration in Colorado.

Events of recent occurrence indicate that dry concentration is to receive an impetus in Colorado, due to the activity of the Sutton, Steele and Steele Manufacturing, Milling & Mining Company. This company succeeds Sutton, Steele & Steele, Inc., of Dallas, Texas. A 50-ton custom and demonstrating mill is being built in Denver, where a tract of three acres has been bought in the south part of the city. It will be ready for operation early this year, and will be the principal testing station of the company. In addition to this mill, the company will operate also the old Yak mill of the American Zinc Extraction Company, at the mouth of the Yak tunnel in Leadville. This mill has been closed for over a year, but has been purchased by the Sutton company, and will be in operation early this year, treating low-grade zinc sulphide ores of the Leadville district. Dry table concentration will be the system used at both these mills.

Company Reports.

The twelfth annual report of the *Consolidated Mercur Gold Mines Company*, Utah, has just been issued, covering the year ended June 30, 1912. In the eleventh report it was shown that the company's operations were on a precarious basis, with a prospect of a complete cessation of work. The present report does not hold out much hope for better conditions, although during the past year some new ore was found which has enabled the company to continue. The total quantity of ore milled was 201,652 tons, consisting of base ore (34 per cent), oxidized ore (59 per cent) and tailing (7 per cent) and yielding a recovery of $2.45 per ton. The mill tailing had an average value of $0.82. The total cost of milling is given as $1.10 per ton. Cyanide consumption was 0.73 lb. per ton of ore; lime consumption was 15.27 lb.; zinc consumption, 0.5 lb.

Synopsis of Chemical and Metallurgical Literature.

Gold and Silver.

Metallurgical Costs at the Homestake.—From an exhaustive treatise on the metallurgy of the Homestead ore, published by Allan J. Clark and W. J. Sharwood, in *Bulletin* No. 98, Inst. Min. & Met., we take the following summary of costs and metallurgical practice:

BREAKING ORE AT SHAFTS.

	Cost per ton.		Approximate Percentage of Total Cost of Breaking.
	Range.	Average.	
	Cents	$	
Power:			
Steam power, including labor of engineers, firemen, etc.	3–4	0.0351	58.5
Attendance:			
Labor, including the handling of cars from shaft to grizzly	1–1.5	0.0125	21.0
Lubricants	0.08–0.14	0.0009	1.5
Maintenance:			
Materials and supplies for repairs and renewals	0.65–1.2	0.0091	15.0
Labor on repairs and renewals	0.14–0.38	0.0024	4.0
Total	5.7–6.6	0.0600	100.0

The cost of distribution of the broken ore to the mills by means of the tramway is approximately 2 cents per ton.

The following costs do not include amortization charges nor water supply; they do, however, cover superintendence, ordinary repairs and renewals, and a proportion of extraordinary renewal charges when the life of an installation may be estimated, as, for instance, the tube-mill lining and the pipe-lines conveying sand and slime.

The cost of *Stamp-milling*, at the lead mills of the company, for a period of twelve months, is as follows:

	Per ton crushed.
Power (including engineer's labor)	$0.104
Machinery (renewals)	0.094
Operating labor	0.091
Silver plating	0.005
Mercury	0.005
Repairs (reconstruction of batteries, bins, etc.)	0.041
Miscellaneous	0.006
	$0.346

At the North Side mills the cost is about $0.27, the difference being almost entirely due to the electric drive at those mills.

Regrinding.—Costs for three-month period, 1910:

	Per ton ground.
Power	$0.0634
Labor	0.0808
Renewals	0.1064
Miscellaneous	0.0064
	$0.2570

METALLURGICAL SUMMARY.

A summary of the metallurgical operations, showing the amounts recovered at the various stages of the treatment, concludes our description. This covers the entire metallurgical system for a period of four months, when the ore was rather below the average in value. The North Side mills, where 36 per cent of the stamps are located, are often supplied with surface ores which are cheaply mined through glory-holes and open-cuts, so that ore of a total gold content of less than $1.50 per ton may be treated at a profit. During the period covered by our summary the ore crushed at these mills averaged $2 gold per ton, while the average for the entire system was $3.59. About 2 per cent of the ore crushed was wasted in the form of slime.

COSTS AT CYANIDE PLANTS, JANUARY-FEBRUARY, 1911, PER TON TREATED.

	No. 1. SAND PLANT: 93,262 TONS.					No. 2 SAND PLANT: 43,609 TONS.					SLIME PLANT: 99,300 TONS.				
	Labor.	Power.	Chemicals.	Other Supplies.	All.	Labor.	Power.	Chemicals.	Other Supplies.	All.	Labor.	Power.	Chemicals.	Other Supplies.	All.
	$	$	$	$	$	$	$	$	$	$	$	$	$	$	$
Transportation	0.0013	.....	.....	0.0015	0.0028	0.0027	.....	.....	0.0001	0.0028	.....	.....	.....	.....	.....
Classification	0.0092	0.0020	.....	0.0001	0.0113	0.0142	.....	.....	.....	0.0142	.....	.....	.....	.....	.....
Thickening	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.0035	.....	.....	.....	0.0035
Neutralization	0.0021	0.0005	0.0188	.....	0.0214	0.0038	0.0003	0.0191	.....	0.0232	0.0057	0.0004	.....	0.0001	0.0062
*Treatment	0.0341	0.0177	0.0939	0.0034	0.1491	0.0332	0.0092	0.0502	0.0031	0.0957	0.0383	0.0181	0.0653	0.0138	0.1355
†Precipitating	0.0059	0.0015	0.0041	0.0008	0.0123	0.0057	0.0009	0.0038	0.0005	0.0109	0.0070	0.0017	0.0067	0.0011	0.0165
‡Miscellaneous	0.0014	0.0016	.....	0.0109	0.0139	0.0028	0.0005	.....	0.0107	0.0140	0.0066	0.0013	.....	0.0054	0.0133
Assaying	0.0039	.....	0.0010	0.0014	0.0063	0.0045	.....	0.0002	0.0005	0.0052	0.0023	.....	0.0007	0.0011	0.0041
Refining	0.0032	.....	0.0011	0.0009	0.0052	0.0028	.....	0.0010	0.0006	0.0044	0.0038	.....	0.0029	0.0018	0.0085
Superintendence	0.0074	.....	.....	.....	0.0074	0.0115	.....	.....	.....	0.0115	0.0099	.....	.....	.....	0.0099
All	0.0685	0.0233	0.1189	0.0190	0.2297	0.0812	0.0109	0.0743	0.0155	0.1819	0.0771	0.0215	0.0756	0.0233	0.1975

COMBINED COSTS: ALL CYANIDE PLANTS: 236,171 TONS.

	$
Labor	0.0744 per ton treated
Power	0.0203 " "
Chemicals	0.0927 " "
Other Supplies	0.0202
	0.2076

CHEMICALS CONSUMED DURING ABOVE PERIOD: LBS. PER TON TREATED.

	No. 1 Plant.	No. 2 Plant.	Slime Plant.	Combined Consump., All Plants.
	lb.	lb.	lb.	lb.
Sodium Cyanide	0.393	0.209	0.225	0.289
Lime	5.01	5.24	4.55	4.86
Zinc Dust	0.065	0.065	0.114	0.086
Hydrochloric Acid	.....	.....	0.499	.....

*Includes filling and discharging. †Includes pumping of all solutions. ‡Includes heating and lighting.

DETAILED METALLURGICAL SUMMARY FOR THE FOUR MONTHS ENDING AUGUST 31ST, 1910.

	VALUE RECOVERED.				WASTED OR LOST IN RESIDUES.			
	Percentage of Total Ore Value.		Value per Ton of Ore Crushed.		Percentage of Total Ore Value.		Value per Ton of Ore Crushed.	
STAMP MILLS—Batteries	35.596		$1.280					
First row plates	27.007		0.970					
Skimmings	2.901		0.104					
Trap sands	1.059		0.038					
Second row plates	3.146		0.113					
Third row plates	1.641		0.058					
Fourth row plates	0.648		0.023					
		71.998		$2.586		.....		.....
RE-GRINDING MILL		0.735		0.026		.....		.....
CYANIDE PLANTS—Sand Treatment	13.737		0.493		4.923		$0.176	
Slime Treatment	7.257		0.261		0.993		0.036	
		20.994		0.754		5.916		$0.212
SLIME NOT TREATED	.....	.....	.....	.....		0.357		0.013
Totals		93.727		$3.366		6.273		$0.225

Total Value of Ore Crushed, per Ton, $3.591.

This Table is very approximately correct. Slight errors exist in the stamp-mill distribution, as the variations in the silver contents of the various amalgams have not been considered, the distribution of the total amalgam value being based on the gold content only. The actual value of the amalgam from the lower rows of plates is therefore a trifle higher than here stated, and the battery correspondingly lower.

Lime-Burning.—Cost of a ton of lime (CaO), delivered on board cars at kiln, twelve-month period:

Stripping and Quarrying—Labor	$1.03	
Supplies	0.04	
		$1.07
Burning and Loading—Labor	$1.13	
Fuel	2.65	
Supplies, Repairs	0.11	
		3.89
		$4.96

Pan renewals, per ton, ground in pans.....$0.125

Tube renewals, per ton ground in tube-mill.... 0.046

Action of Calcium Sulphate on Cyanide Solutions.—In the *Journal* of the Chem. Met. & Min. Soc. of S. Africa for August, 1912, JOHN WATSON contributes some data on the effect of calcium sulphate on cyanide solutions, being a discussion of an original paper in the April, 1912, issue of the same journal, by ANDREW F. CROSSE. Mr. Watson made some

experiments to ascertain the extent to which calcium sulphate decomposes a solution of potassium cyanide. Mill solutions used for sand and slime treatment respectively, were divided into separate portions and placed in bottles containing one litre each. To one portion of each kind of solution he added 2.5 g. of pure dried calcium sulphate and agitated well. The bottles were allowed to stand unstoppered in the laboratory, and were shaken each day. The following table gives the results of tests made on treated and untreated samples of solution.

Time of Analysis.	UNTREATED SAND SOLUTION.		TREATED SAND SOLUTION.	
	Free KCN.	Alkalinity CaO.	Free KCN.	Alkalinity CaO.
As taken from sump	0.223%	0.059%	0.223%	0.059%
Three and one-half hours after addition of $CaSO_4$	.....	.....	0.214	0.059
After 2 days.....	0.214	.....	0.202	0.059
After 4 days.....	0.192	.....	0.184	.....
After 12 days.....	0.183	0.053	0.164	0.048
Percentage loss of KCN and CaO.....	17.93	10.2	26.45	18.6

A similar table shows results obtained on the solution used for slime treatment, in which the percentage loss of KCN and CaO were 46.8 and 52.8 for the untreated, and 59.3 and 87.6 for the treated solution. It must be remembered that the untreated solutions contained some calcium sulphate.

In a solution of sodium cyanide prepared with distilled water, and having the approximate strength of the sand solution used before, Mr. Watson added 1 g. lime to 2700 c.c. and divided the solution in three parts and allowed to stand for one day. Then to one part he added 2.07 g. $CaSO_4$, to another 29.7 g. Epsom salt, leaving the third portion untreated except with the previously added lime. Tests were then made on the consumption of KCN and CaO as before, with the result that after seven days the following percentage losses of KCN and CaO were noted: In the untreated solution, 0.4 and nil; in the $CaSO_4$ solution, 4.1 and 5.1; and in the Epsom salt solution, 22.3 and 26.4.

Cyanide Practice at Komata Reefs Mill, New Zealand.—In the *Mexican Mining Journal* for November, 1912, S. D. McMiken describes the changes made in the treatment of the Komata Reefs ore. Originally the ore was dry-crushed in stamps and cyanided. This failed to recover much coarse gold, so wet-crushing and amalgamation were adopted preceding cyanide treatment. Still later the process has been altered to include fine-grinding and slime treatment.

The ore, which is a hard, cherty quartz mixed with calcite and containing little sulphide, is crushed to 1½-in. size and fed to twenty stamps. The mortars are fitted with screens having 4½ holes per linear inch. Stamp capacity is 5 tons per stamp per 24 hours. The stamp product is roughly classified in pointed boxes, the underflow being fed to tube-mills at a consistency of 1:1. The tubes are 16 ft. by 4 ft., lined with Brown patent liners which last twenty-two months, grinding 28,500 tons of ore. The consumption of iron is 0.48 lb. per ton of ore, and of pebbles 2.2 lb. per ton of ore. Power required for two mills is 50 hp, the tubes running at 28 r.p.m. The following table shows the work done by the mills.

	On 20 Mesh %.	On 60 Mesh %.	On 90 Mesh %.	On 200 Mesh %.	Through 200 Mesh %.
Tube-mill feed...	25.5	25.2	16.5	14.8	18.0
Tube-mill discharge.....	....	1.0	22.0	25.9	51.1

The finely-ground pulp is amalgamated on Muntz metal plates. This metal has been found superior to copper, being more easily kept clean, and absorbing less gold. Forty per cent of the gross value of the ore is saved by amalgamation.

After amalgamation the pulp is separated into sand and slime, which receive separate treatment.

The sand contains 40 per cent of material which will pass 200 mesh. Percolation is carried on in steel vats with filter bottoms of jute sacking. The sand is drained to 15 per cent moisture and treated with a wash of 0.05 per cent KCN solution. After percolation this wash is precipitated and run to waste. It serves the purpose of reducing the consumption of cyanide when the strong solution is put on, as it contains considerable lime. A strong solution of 0.8 per cent KCN is then run on and circulated through the sand for eight days before precipitation. It is aerated and treated also with ozone which is found to increase its activity. The strong solution is followed by one of 0.08 per cent KCN and then by water. The usual time of washing is fourteen days. Extraction is 93 per cent of the value of the sand.

The slime is thickened in Dorr thickeners, being first treated with lime at the rate of 20 lb. per ton. The Dorr discharge contains 40 per cent moisture. It is pumped to the Brown (Pachuca) agitators which are 38 ft. high and 10 ft. diameter. Power required for ten agitators is 8 hp, the air being compressed to 22 lb. per square inch. These tanks have been tried with short air-lift pipes, but they did not prove satisfactory on account of the tendency of the coarse slime to separate from the fine. The slime in the agitators is diluted with 0.1 per cent KCN solution until it contains about 65 per cent moisture. A common charge is 40 tons dry slime. Air agitation continues for five or six days, after which time the pulp is again thickened to about 45 per cent moisture. The overflow from this thickening is filtered through sand and precipitated. The thickened slime is filtered in a Moore filter of the "turnover" type invented by Mr. McMiken. A vacuum pump giving a vacuum of 24 in. mercury builds a cake 1¼ in. thick in 30 minutes. A wash of barren solution is given for about the same length of time required to build the cake. No water wash is given. The cake is discharged with 25 per cent moisture, with a loss of soluble gold amounting to 12 cents per ton, and of silver 4 cents per ton. The total extraction is 95.6 per cent of the value of the slime.

Precipitation is by zinc dust. The precipitate is given a sulphuric acid treatment (10 parts water to 1 of acid), after which it is dried and mixed with powdered borax glass in the proportion of five parts precipitate to one of borax. Melting is done in plumbago crucibles. The bullion is 900 fine, the ratio of gold to silver being 1:8. Amalgam from the plates yields bullion 990 fine, containing gold 600 and silver 390.

The total extraction from this ore is 96.4 per cent. This high extraction is assigned mainly to having large cyanide capacity per stamp.

Gitsham Cyanide Process.—The Kalgoorlie *Miner* gives some details of this modified cyanide process, in which ordinary potassium cyanide solution is acidified with sulphuric acid, giving rise to hydrocyanic acid. The solution is allowed to percolate through the ore in the usual way, but before precipitation it is neutralized with lime water. After precipitation it is again acidified and used as an extractor. The inventor claims that antimonial and copper ores can be worked without trouble, and that refractory ores generally yield their precious metals to this solution.

Photolyse.—Under this caption Gaston Jacquier describes in the *South African Mining Journal* for Sept. 14, 1912, a process of precipitating cyanide solutions, in which photochemical effects play a part. Wooden tanks are provided with removable aluminium linings, and aluminium sheets are adapted to be suspended in the tank. The latter are arranged at right angles to the direction of the magnetic needle, and must be exposed to the sunlight. After twenty-four hours exposure all the gold and silver contained in the solution is precipitated on the aluminium sheets which are then removed and brushed to collect the precipitate. The aluminium does not in any way change or lose weight. The reader will recall in this connection the "luminator" purification of water, mentioned in our issue for November, 1912, page 762, in which

aluminium is used in direct sunlight for the treatment of water for boilers. Here also a photochemical effect is suggested, as the aluminium does not change nor lose weight.

Estimation of Lead in Cyanide Solution.—In the *Mexican Mining Journal* for December, 1912, J. E. CLENNELL gives methods for determining lead in cyanide solutions. For rapid approximate determinations the author proceeds as follows:

The solution is filtered if necessary, and 100 c.c. is agitated with an excess of sodium carbonate or bicarbonate, usually 0.3 to 0.4 g. is sufficient. The precipitate which consists almost exclusively of lead and calcium carbonates, without copper, gold or silver, is allowed to settle, and is then washed on a filter until free from cyanide. The residue is then dissolved in hot 20 per cent acetic acid, and the liquid transferred to a measuring flask of from 100 c.c. to 500 c.c. capacity. A measured volume of standard potassium bichromate solution is then added, more than sufficient to precipitate the lead, and the flask filled to the mark with distilled water. After thorough agitation the precipitate is allowed to settle, and an aliquot part of the solution drawn off in a pipette. Filter if necessary. The excess of bichromate is titrated with a ferrous sulphate solution of corresponding strength, first adding a few drops of hydrochloric acid. Potassium ferricyanide is used as an indicator as in the bichromate titration for iron. The bichromate and ferrous sulphate solutions should be standardized against a lead solution of known strength. A convenient standard is one containing 1 g. lead per litre. One gram of pure lead foil is dissolved in the least possible quantity of dilute nitric acid, sodium carbonate is added until a permanent precipitate is formed, and then acetic acid until everything is in solution. The solution is made up to one litre with distilled water.

An alternative method is as follows: 100 c.c. cyanide solution is heated to boiling and a slight excess of sodium sulphide added. One or two cubic centimeters of a 10 per cent solution is sufficient. The precipitate contains sulphides of lead, silver, zinc and possibly mercury. Wash by decantation and finally on the filter until the residue is free from soluble sulphides. Wash the precipitate off the filter and cleanse the latter with 10 c.c. of boiling 50 per cent nitric acid, allowing the liquid to run into the vessel containing the precipitate. Concentrate to small bulk, cool, remove globules of sulphur, add 10 c.c. sulphuric acid and evaporate to white fumes. Cool, add 50 c.c. water and boil; cool and allow to settle, using 10 or 20 c.c. alcohol if the precipitate is small. Filter and wash with 5 per cent sulphuric acid. The filtrate contains the zinc and silver. Dissolve the lead sulphate in sodium or ammonium acetate, transfer to a measuring flask and add bichromate solution as in the preceding method and finish as there indicated.

Flotation of Minerals.

"Agitation Froth" Process.—In our last issue we published an abstract of an article by J. W. ASHCROFT, taken from *Bulletin* No. 97, Inst. Min. & Met., describing the operation of the flotation process on a copper ore in New South Wales. In *Bulletin* No. 98 of the same society, Mr. H. L. SULMAN gives a discussion of Mr. Ashcroft's paper, in which some essential details of the minerals separation process are given. Mr. Sulman suggested that the term "froth flotation" or "agitation froth" process be applied to the method under discussion, since an essential factor in successful treatment was the obtaining of a thick, substantial or "matted" froth, necessary to support the coarser mineral particles. If the floating mass becomes thin or skin-like, it does not afford the same opportunity to recover coarse mineral. If necessary, the area of the flotation chamber has to be constricted to produce a thick froth.

By mere vigorous agitation of ore and water and the addition of a minute proportion of oil, say 2/3 lb. crude eucalyptus oil per ton of dry ore (as in the case under discussion), froths were produced which carried over 80 per cent of the total mineral as a concentrate assaying over 20 per cent copper. This was obtained from an ore assaying only 3½ per cent copper. From poorer ores the flotation process was obtaining elsewhere 90 per cent of the mineral as a concentrate containing 22 per cent or 23 per cent of the metal.

While the process is by no means a delicate one and requires no intricate adjustments or highly skilled supervision, certain conditions are demanded, as follows:

The ore sent to the flotation department should be of uniform consistency, say four or five parts water to one of ore.

The feed should be uniform as to rate of flow and mineral content. If either factor is subject to wide variation, plant adjustment would be required accordingly.

The mesh to which the ore is crushed should be that at which the best results can be obtained, and should be determined for each ore.

The power applied to the agitation spindles should be uniform; the agitation should not be alternately rapid and slow.

Failure to apply these conditions will give poor results which cannot properly be charged to the process.

The "froth flotation" process is now being applied to a wide variety of ores; zinc-lead, copper, silver, molybdenum and others. At the Braden mine, South America, a plant is installed to treat 3600 tons per day of low-grade chalcopyrite.

The power required for agitation is about ½ hp to ¾ hp per box; thus an eight-box unit would require about 6 hp. The agitation shafts revolve at about 300 to 350 r.p.m., the peripheral speed of the impellers being some 1500 ft. per minute. The cost of a flotation plant of this type is far less than for a wet concentration unit of similar capacity.

Mr. WALTER BROADBRIDGE contributed the following data regarding the flotation methods at the Braden Copper Co., in Chile. A change was made at this property, substituting the minerals separation process for wet concentration of low-grade copper ore. At present a 3000-ton flotation plant is under construction. The copper minerals are chalcopyrite, bornite, chalcocite, cuprite, metallic copper and the carbonate and silicates of copper. The recovery by wet concentration is given as 50 per cent to 60 per cent. In a test run by flotation the averages were as follows: Ore, 2.61 per cent copper; tailing, 0.56 per cent; concentrate, 21.19 per cent; recovery, 80 per cent. Consumption of chemicals was 3.57 lb. H_2SO_4 and 2.33 lb. Texas and wood tar oils, per ton of ore treated. The estimated cost was 10d. ($0.20) per ton, based on a treatment of 1,000,000 tons per annum.

Combustion.

Surface Combustion.—In *Feuerungstechnik* of November 15, 1912, Dr. **C. Kinzbrunner** reviews the different theories which have been proposed by Schnabel, Bone, Ellis, Leather and Lucke concerning the mechanism of "surface" or "flameless combustion" and reaches the conclusion that its essential feature is the combustion of large quantities of gas and air in approximately theoretical proportion concentrated into a small space, while the use of porous refractory materials permits an automatic regulation of the combustion zone within the pores of the mass and the incandescent surfaces exert a strong catalytic effect. The combustion is not flameless, but as the place of the flame is within the incandescent porous mass, it is not visible to the outside. "With respect to its practical applications the invention may become of about the same importance for the technics of firing as the invention of the incandescent gas mantle has become for lighting."

Recent Chemical and Metallurgical Patents.

Iron and Steel.

A method of treating metal ingots to prevent piping and segregation has been patented by GEORGE H. BENJAMIN, of New York City. As a preliminary step in the production of the ingot, the molten metal is poured into a mold which is so constructed that one of its sides shall have a higher temperature than the other three sides. This may be accomplished by heating one side of the mold or by providing cooling means for the other sides. By casting the ingot in such a mold one of its

sides will retain a higher temperature than the others and the soft metal on the hotter side will accommodate the shrinkage on the cooler sides and prevent the formation of pipes. When the ingot is cool enough to handle it is removed from the mold and placed in a machine between pressure plates mounted on shafts and carried in suitable bearings. One of the plates has an adjustable part that can be used to compress a part of the soft side of the ingot while cooling takes place. Also, during the exertion of this pressure, the ingot can be rotated to overcome the tendency toward segregation of the materials forming the ingot. (1,038,271, Sept. 10, 1912.)

Gun Barrel and Similar Steel.—Franz Hatlanek, of Kladno, Austria, endeavors to improve the wearing qualities of steels which are subject to repeated alternating heating and cooling, such as the barrels of guns and cannons. The continual expansion and contraction of such steel causes a destruction or a change in the texture of the material which weakens it. The metal is then less capable of enduring any other additional strains. An addition of from 4 per cent to 5 per cent copper is said to perform this improvement. It has the further advantage of making the steel more indifferent against the action of residues of the combustion of explosives. The pits and spots of rust which form in an insufficiently cleaned weapon impair its shooting accuracy considerably. It has been found that a steel with 7 per cent Ni and 4 per cent Cu did practically not rust in a moist atmosphere of nitric acid, nitric anhydride and carbonic acid. The resistance to rusting becomes specially evident when the percentage of nickel in a gun steel is made slightly higher than the usual 3 per cent. (1,005,115, Oct. 3, 1911.)

Flue Dust.

Dust Separators.—Devices for separating dust and solid particles from blast-furnace gases by subjecting them to centrifugal action have been patented by several inventors. Recently Julius A. Dyblie, of Joliet, Ill., has proposed the device shown in vertical and horizontal sections in Fig. 1. The vertical section is on line 1-1 of the horizontal, and the latter on line 2-2 of the former.

The catcher consists of a casing 10 mounted on a base 11. The dust-laden gas enters at 18 and passes through the spiral passage 21.

The dust is forced to the outer edge of the spiral and falls through its open lower edges into the dust-collecting chamber 12, and thence to the outlet 14, where it is held by the cap 15 until removed. A certain portion of the dust is caught also by the hook 25, and drops downward into the collecting chamber.

The clean gas passes through the aperture 24 into the central chamber 22 and thence upward into the portion 30 of the dust-catcher to the outlet pipe 31. Any dust which passes into the central chamber 22 can pass downward by gravity to the chamber 12. (1,045,532, Nov. 26, 1912.)

In Fig. 2 is shown the device of Lawrence Anderson, of Chicago, Ill., in its relation to a blast furnace. The separator consists of a metal pipe C^1 having the form of a helical coil C. The force of the blast from the furnace drives the dust-laden gas through the coil, throwing the solid particles to the outer surface thereof. Here they are arrested in the pockets d^3 from which lead pipes d^1 ending in extensions d^2, which dip into water, thus sealing the pipes against the exit of gas. The coil shown is divided into three parts of four convolutions each. In the first a dry separation takes place; in the second a water spray is introduced by the water pipe G^1 and its extensions. In the third section the cleaned and washed gas is dried by centrifugal action, and finally delivered to a tank connected with the outlet C^3. (1,039,008, Sept. 17, 1912.)

Treatment of Flue-Dust.—John I. Souther, of Westmont, Pa., has patented a method of treating flue-dust by agglomerating or sintering it into a rough lumpy condition by means of high heat applied to the dust in a revolving cylindrical furnace, using blast-furnace gas as a fuel. (1,041,363, Oct. 15, 1912.)

Zinc, Copper and Nickel.

Zinc Digester and Filter.—One of the patented features of the zinc reduction process of Percy C. C. Isherwood, of Leytonstone, England, is a digester and filter illustrated in Fig. 3. The patent is assigned to the Refractory Zinc Ore Treatment Company, a corporation of New York. The object

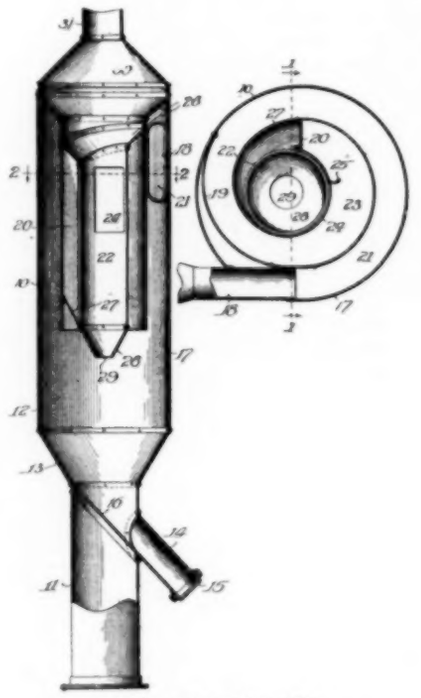


FIG. 1.—DUST COLLECTOR.

of this invention is to provide means for filtering a solution of zinc while hot, so that the zinc salt cannot crystallize out of the solution. The digester consists of a vessel *a* mounted on trunnions and adapted to be inverted. The cover *b* has a valve *d*, and when in place holds a filter *c* at the point shown. A mixer *e* is used to stir the charge of zinc-bearing material during the process of solution. Heat may be applied in any manner, as by a gas burner *f*. When solution is complete the digester is in-

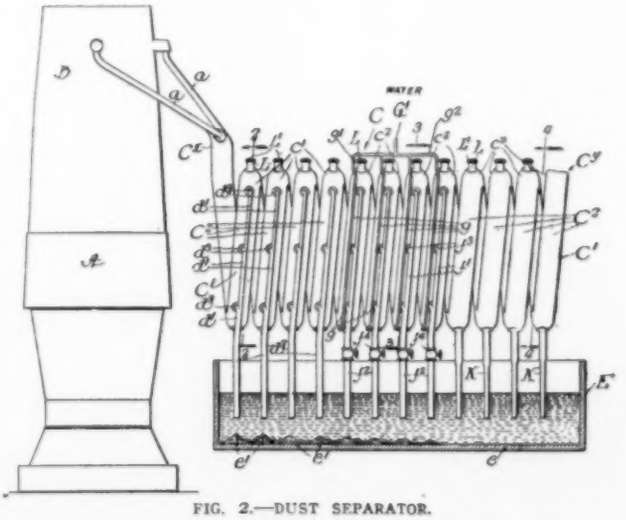


FIG. 2.—DUST SEPARATOR.

verted, whereupon the mass within falls on the filtering medium and the zinc liquor passes through due to the pressure inside the tank. The operation is similar in some respects to that of a chlorination barrel, but is only one step in a process which involves solution of zinc in sulphuric acid and ultimate electrolysis. (1,043,939, Nov. 12, 1912.)

Repairing Copper Converters.—An invention designed to facilitate the repair of converters has been patented by E. A. C. SMITH, of Baltimore, Md. Usually it has been necessary, in repairing a large converter, to remove it from service and allow it to cool sufficiently to permit a workman to enter it. Mr. Smith has patented a feature which will make the region of the tuyeres accessible without the usual trouble and expense. The arrangement is such that a portion of the casing may be removed so that the lining in the tuyere zone can be reached from without by the workman. The use of the invention permits the repair of tuyeres and lining within a few hours, whereas formerly several days were required for the same work. When it is desired to repair the lining at any point along the tuyere zone, or to remove a corroded or defective tuyere, the casing section nearest the point of repair is removed, thus leaving an aperture through which the repair can be made. On completing the work, the removable section is replaced and wedged in position. (1,044,587, Nov. 19, 1912.)

Hardening Copper.—The use of potash, ferrosilicon and limestone in different proportions and modified by the addition of other ingredients is the basis of a patent granted to JULIAN KICH, of Lyndora, Pa. As an example of a mixture which will give the desired result, the inventor uses the following: ½ oz. each of ferrous sulphate, copper sulphate, ferrosilicon, potash, limestone, manganese, phosphorus, and welding compound. The last is composed of boric anhydride, 50 per cent; iron oxide, 15 per cent; soda, 15 per cent, and potash 20 per cent. The mixture first mentioned is added to molten copper in the proportion of 1:3. Modifications of the formula are claimed to give different results. (1,041,297, Oct. 15, 1912.)

Purifying Metals.—For the purification of copper and other metals, particularly for the removal of arsenic, AXEL G. SUNDBERG, of Helsingborg, Sweden, has patented the use of an alkali carbonate. In practice the inventor prefers to add the alkali carbonate, say sodium carbonate, to the bath of

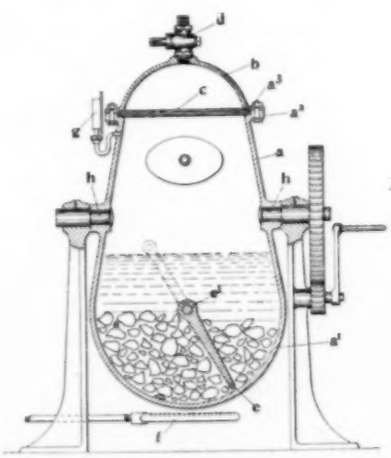


FIG. 3.—ZINC DIGESTER AND FILTER.

molten copper by introducing it in a current of air or gas beneath the surface of the metal. This procedure effectually removes arsenic which may be combined as arseniate of copper, forming sodium arsenate, which rises to the surface as a slag. Copper containing 0.02 per cent arsenic has thus been purified to an arsenic content of 0.002 per cent by blowing in sodium carbonate in quantity less than ½ per cent of the copper. (1,043,371, Nov. 5, 1912.)

Alloys.—A brass possessing valuable qualities has been patented by ALFRED SCHMID, of Zürich, Switzerland. To an alloy of copper and zinc he adds, as an exclusive adjunct, silicon and tin. This produces a metal of high limit of elasticity, toughness, soundness, resistance to the attack of salt water, dilute acids and alkalis, and no undue resistance to cutting tools. The following example is given: 58 lb. copper is melted and superheated; to this is added, while stirring, 40 lb. zinc, 1 lb. tin, and 1 lb. silicon copper, the last containing 30 per cent silicon. Such alloys have a limit of elasticity of 12.7 to 19 tons per square inch, tensile strength of 30.5 to 34.9 tons per square inch, extension of 25 to 35 per cent, and a high resistance to the notch bending test. They can be drawn, rolled and hammered at normal temperature, and can be wrought, rolled and pressed when hot. (1,040,027, Oct. 1, 1912.)

The economical manufacture of brass on a large scale is the basis of a patent granted to LAWRENCE ADDICKS, of Chrome, N. J. He proposes to melt copper in a reverberatory furnace, such as is used for copper casting, having a capacity of from 20 to 250 tons per twenty-four hours. By means of a suitable ladle, several tons of copper is withdrawn from the furnace and the necessary quantity of zinc added and quickly incorporated. The 2 or 3 tons of brass is then promptly cast from the ladle into ingots. (1,041,940, Oct. 22, 1912.)

Alloy of Titanium and Copper.—ISADOR LADOFF, of Cleveland, Ohio, has patented a method of alloying or compounding titanium and copper without melting the same at the high temperature which would be required for the combination of the primary metals. He uses the oxides of the two metals, TiO_2 and CuO, and incorporates with them a suitable binder, such as oil. The mixture is then molded into any desired shape and introduced into a muffle furnace where it is subject to the action of a reducing atmosphere, such as carbon monoxide, at a temperature of from 600 deg. C. to 800 deg. C. To further insure the reducing atmosphere the molds may be packed in powdered coke. At the temperature mentioned the reduction proceeds, starting with the copper oxide and continuing catalytically with the titanium oxide. The reduction and combination is thus said to be effected at a temperature below the melting point of copper. (1,042,694, Oct. 29, 1912.)

Nickel.

Reduction of Copper-Nickel Ores.—According to patent specifications recently issued to WILHELM BORCHERS, of Aachen, Germany, and HARALD PEDERSEN, of Trondhjem, Norway, the following process may be successfully used in the treatment of copper-nickel ores:

First, the ore is smelted, preferably in the electric furnace, producing a crude matte containing practically all the nickel and copper originally contained in the ore.

Second, the crude matte is roasted in such a manner that both copper and nickel are for the most part converted into sulphates, while the iron forms oxide. This can be done at a temperature of 600 deg. C.

Third, the copper and nickel sulphates are dissolved with acidulated water obtained by passing the roaster gases in a counter stream of water in a percolation tower. This water will contain sulphurous and sulphuric acids.

Fourth, the residue from this leaching operation, consisting principally of iron oxide, but containing also undissolved copper and nickel, is resmelted to form new matte. As the iron oxide favors the oxidation of iron sulphide to oxide, and therefore into slag-forming material, it aids in the formation of a richer matte.

Fifth, by adding calcium or sodium sulphide to the solution obtained from the leaching process, copper is precipitated as a sulphide. After separating this by filtration more calcium or sodium sulphide is added for the precipitation of the nickel as sulphide.

Sixth, the sulphides thus separately obtained are reduced to their respective metals by smelting with suitable fluxes, say, limestone and carbon. Calcium sulphide will be obtained as a slag.

Seventh, tthe calcium sulphide obtained from the sixth operation is converted into sodium sulphide, if desired, by treating with suitable sodium compounds, as sodium sulphate in aqueous solution. The sodium sulphide thus obtained is used as a precipitating agent, in the fifth step, thus giving sodium sulphate solution which may be reduced to sodium sulphide by more calcium sulphide.

None of the steps in the process is novel in itself, but in combination they form a useful and economical method, possessing several advantages over previously proposed methods. In

the smelting tests, slags were made containing less than 0.1 per cent copper and nickel. (1,043,291, Nov. 5, 1912.)

Another process for the same purpose has been patented by Horace L. Wells, of New Haven, Conn. He takes a matte of copper and nickel, produced by smelting their ores, and grinds it to a fineness of 60-mesh. The matte is then treated with dilute hydrochloric acid (18 to 25 per cent HCl) at a temperature between 110 deg. Fahr. and 212 deg. Fahr. Most of the nickel will be extracted at the first application of acid, but a second is necessary to complete the extraction. The second acid solution thus obtained may be used on fresh matte. (1,044,316, Nov. 12, 1912.)

Aluminous Abrasive Material.

The production of a new abrasive is patented by August F. Blouin, of Springfield Township, Delaware County, Pa. An example of his material is given as follows: 100 lb. of an aluminum ore containing 78 per cent Al_2O_3, 12 lb. anhydrous borax, 0.3 lb. chromite, and 4.75 lb. carbon. The mixture is fused in an electric arc furnace and the product crushed and cleaned for abrasive purposes.

Furnaces.

Improved Grondal Furnace.—An improvement in furnaces of the channel type has been patented by Nils V. Hansell, of Bloomfield, N. J., and assigned to the American Grondal Company, a corporation of New York. In furnaces conforming to the Grondal patent it is customary to load the briquet trucks at some distance from the furnace and feed them to a preheating chamber which is aligned with and forms a continuation of the furnace proper. Where land is valuable this form of furnace requires too much ground, and it is the object of the present invention to provide a furnace requiring less space as to length. Furthermore, in the old type of furnace it is customary to mingle the air blown beneath the trucks to cool them, with the combustion gases after they have left the combustion chamber, and discharge them through a common stack. The combustion gases, however, contain valuable by-products which may be recovered and it is another object of the improved furnace to keep the cooling air and combustion gases separate and thus avoid diluting the latter.

In the new form of furnace the preheating chamber is located adjacent and parallel with the combustion chamber. The latter is graded upward from its entrance to discharge point, so that the newly loaded trucks may return by gravity through the preheating chamber. In the combustion chamber the gases of combustion and the cooling air are kept separate by the usual means of a sand seal on the sides of the furnace. In the entrance vestibule of the combustion chamber, however, it is necessary to provide some means of preventing the air and gas commingling as the truck is fed into the chamber. This is accomplished by means of a shield which follows each car into the chamber and maintains the gas above the trucks separate from the cooling blast beneath it. (1,043,695, Nov. 5, 1912.)

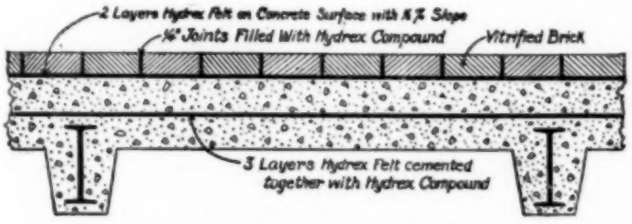
Acid-Proofing the Floors of Battery Rooms.

A great deal of attention is being given to the proper method of acid-proofing the floors of battery rooms. It is recognized that nothing can be done to make a concrete floor in itself acid-proof. They have been treated with linseed oil thinned down with gasoline, but this method has retarded the action of the acid only temporarily. Acid-proofing preparations have been tried out by one of the leading concrete construction companies of New England but have not proved a uniform success.

The general construction of the floor of a battery room consists of vitrified brick or tile placed on a concrete base. Leading authorities state that the best way to acid-proof such a floor is to place several layers of acid-resisting felt cemented together with an acid-resisting compound between the brick and the concrete. The correct way to do this is first to give the concrete floor a coating of hot compound, then lay in this several thicknesses of felt, lapped so that the joints of one layer break joints with the under layer. Where this procedure is followed it is necessary to use sand for embedding the brick. To protect the walls and any columns in the battery room it is advisable to turn up the felt for a foot or so at the walls or columns, putting three courses of brick against the felt and pouring the compound behind the brick so as to make a tight joint.

The New York Edison Co., which is noted for using large factors of safety in all of its construction, takes extra precautions in acid-proofing floors. They usually specify two distinct courses of several layers of acid-resisting felt cemented together with acid-resisting compound.

In one of the recent specifications of this company for the floors of a transformer and battery station, it is stated that the contractor should spread over the rough concrete floor a layer of 1½-in. cement mortar finished with a smooth surface. As far as acid-proofing is concerned the specifications were as follows:


2 Layers Hydrex Felt on Concrete Surface with ¼" Slope
¼" Joints Filled With Hydrex Compound
Vitrified Brick
3 Layers Hydrex Felt cemented together with Hydrex Compound

ACID-PROOF FLOOR CONSTRUCTION.

"Over the cement motar surface shall be laid three layers of Hydrex felt bonded with Hydrex compound. The cement surface shall first be coated with a continuous and uniform layer of compound, to which it must adhere at every point. Where the felt is turned up on the walls and drain boxes an additional layer of felt and compound running parallel with the intersection of the two plane surfaces shall be applied.

"Over the completed acid-proof course shall be applied a layer of compound.

"Immediately after the acid-proofing is cool or soon enough after to insure against damage, the contractor shall spread a layer of cement mortar about 1½ in. thick over the entire horizontal area of the acid-proof course. This will form, after setting, a working surface on which the rest of the work shall be built."

After the protecting layer of cement mortar has set the specifications call for a course of concrete with a cement mortar finish and on top of this a second layer of acid-proofing consisting of two layers of the acid-resisting felt with three courses of the hot compound. Upon the top of this last acid-proofing course was laid bricks, the joints of which were filled with the hot compound as specified above.

It is interesting to note that the tests of the New York Edison Company have shown that the felt and compound used in this connection are not at all affected by sulphuric acid solutions.

An Improved Metallurgical Microscope.

By Wirt Tassin.

The value of metallographic methods in mill control has been recognized but the usefulness has been limited by the lack of portability in the appliances necessary for their use. This has made it difficult to study the forging, the casting or the bar as a whole, with the result that the metallographic field has to a large extent been limited to the examination of more or less small specimens cut from the piece and which may or may not be representative of the mass.

In June, 1910, I described in the *Iron Age* an illuminator which, attached to the metallographic microscope materially increased its compactness. I now propose to describe a com-

plete metallographic outfit which is light, compact, and portable and may be used either in the mill or in the laboratory and is equally serviceable for the study of the ingot, the forging, the bar, the casting or the small specimen, and which, it is believed, will meet the needs of the metallurgist, the engineer of tests, and the inspector.

The apparatus consists of a camera, microscope and illuminating device, all self-contained (Fig. 1).

The illuminating device consists of a tube which carries the lenses and is mounted in a sleeve provided with a set-screw to lock it in any position. Attached to this sleeve by means of a trunnion is a hanger. This is fastened by a set-screw to an arm which locks into the barrel of the microscope. The rear of the tube carries a shield which is provided with clips to hold the source of light when electricity is used and is slotted to hold a rod and lamp carrier when gas is used.

The source of light may be an acetylene jet or an electric lamp.

When acetylene is used the gas may be obtained from a generator or from a "Prestolite" tank. The lamp is a "Twentieth Century" jet, the support for which is held in a carrier made of two pieces of tubing brazed together at right angles. Each piece is provided with a set-screw so that the jet may be moved up or down, front or back, turned on its axis and set at any desired distance with reference to the plane of the lenses of the condensing train. The apparatus as arranged for illuminating with gas is shown in Fig. 2.

When electricity is used the lamp is carried in a socket fixed in an insulated metal hood. The whole is held in position with reference to the lenses of the condensing train by means of clips fastened to the shield. This arrangement provides for an up and down movement of the light. The apparatus as arranged for illuminating with electricity is shown in Fig. 1.

The current may be obtained from an accumulator or by cuting down the street supply. A convenient lamp bank to reduce street current for use with Mazda miniature lamps is wired as in Fig. 3. The lamp resistance needed with a 110-volt current is:

Two 32-cp and one 16-cp carbon lamps for a 6-volt, 16-cp Mazda miniature lamp.

One 32-cp and one 8-cp carbon lamp for an 8-cp Mazda miniature.

One 32-cp and one 4-cp carbon lamp for a 6-cp, 6-volt tungsten.

One 4-cp and one 16-cp carbon lamp for a 4-cp, 6-volt tungsten miniature lamp.

The lamp recommended is a 6-volt, 16-cp, headlight Mazda, No. 12 G., candelabra base.

The microscope consists of a barrel and draw tube mounted on a handle arm and provided with a coarse and fine adjustment, the latter of the lever type. Attached to the barrel just below the draw tube is a collar which holds a rod controlled by a set-screw. The base of this rod rests on the handle arm. The arrangement prevents the possibility of the coarse adjustment overhauling when the camera is in use. The base of the microscope is the stage. Through the center of this is a 1-in. circular opening which affords free space for the objective when examining large masses below the stage. Leveling screws are provided which permit of the adjustment of the apparatus perpendicular to nearly any surface. The advantages of this are to be seen in Fig. 1 where the microscope is shown mounted on a 6-in. shaft. Provision is made for the use of a detachable mechanical stage when needed.

The camera is attached to the barrel of the microscope by a tube which slips in and out like the draw tube and may be removed with the same ease. The whole moves with and becomes a part of the barrel so that any degree of focusing is possible. The distance between the eye piece and the ground glass is a constant, so that the amplification is a standard for all magnifications. The image is 3¼ in. in diameter and is formed on a 3½ x 3½-in. plate. The time required for the exposure is rarely over 10 seconds.

The apparatus packs in a space 12 x 12 x 5½ in. A suit case fitted with compartments to hold the various parts makes a very convenient container. One that measures 12 in. in width by 24 in. long by 6 in. deep, will hold the camera, the microscope and all its accessories, the lamp bank or an acetylene

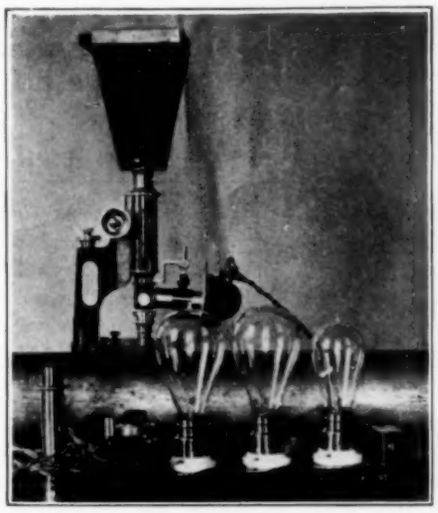


FIG. 1.—MICROSCOPE CAMERA, ILLUMINATING DEVICE AND LAMP BANK, AS USED WITH ELECTRIC LIGHT AND MOUNTED ON A CINCH SHAFT.

generator of the "Neverout" type, four plate holders, four boxes of plates, two tanks, one for developing and one for fixing, together with the chemicals necessary for etching and for developing. The suit case when fitted with a curtain also serves as a dark room.

In examining a large piece such as an engine frame the surface is "spot polished" in as many places as desired. A dam of modeling wax is then built around the spot to hold the etching medium and when the etching has been completed the dam is broken, the surface washed with water and gasoline and the

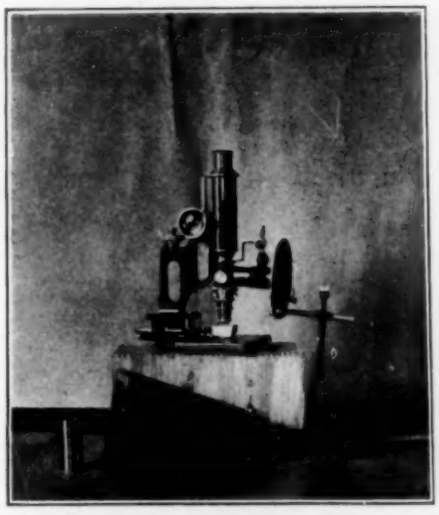


FIG. 2.—MICROSCOPE, CAMERA DETACHED WITH ACETYLENE LIGHT AND MECHANICAL STAGE

microscope adjusted and all is ready for the visual examination and the taking of a photographic record.

To polish, use is made of a portable ¼-hp motor with a flexible shaft. As it is almost impossible to hold a wheel steady in the hand to give a surface flat enough for a microscopic examination use is made of a steady rest somewhat like the "Old man" of a drill. This insures a uniform bearing for the grinding wheel and with the proper gradation of the abrasive a mirror polish is obtained without much difficulty. A 130 F. car-

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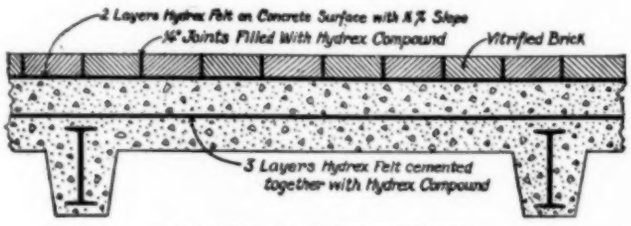
Acid-Proofing the Floors of Battery Rooms.

A great deal of attention is being given to the proper method of acid-proofing the floors of battery rooms. It is recognized that nothing can be done to make a concrete floor in itself acid-proof. They have been treated with linseed oil thinned down with gasoline, but this method has retarded the action of the acid only temporarily. Acid-proofing preparations have been tried out by one of the leading concrete construction companies of New England but have not proved a uniform success.

The general construction of the floor of a battery room consists of vitrified brick or tile placed on a concrete base. Leading authorities state that the best way to acid-proof such a floor is to place several layers of acid-resisting felt cemented together with an acid-resisting compound between the brick and the concrete. The correct way to do this is first to give the concrete floor a coating of hot compound, then lay in this several thicknesses of felt, lapped so that the joints of one layer break joints with the under layer. Where this procedure is followed it is necessary to use sand for embedding the brick. To protect the walls and any columns in the battery room it is advisable to turn up the felt for a foot or so at the walls or columns, putting three courses of brick against the felt and pouring the compound behind the brick so as to make a tight joint.

The New York Edison Co., which is noted for using large factors of safety in all of its construction, takes extra precautions in acid-proofing floors. They usually specify two distinct courses of several layers of acid-resisting felt cemented together with acid-resisting compound.

In one of the recent specifications of this company for the floors of a transformer and battery station, it is stated that the contractor should spread over the rough concrete floor a layer of 1½-in. cement mortar finished with a smooth surface. As far as acid-proofing is concerned the specifications were as follows:


2 Layers Hydrex Felt on Concrete Surface with ¼" Slope
½" Joints Filled With Hydrex Compound
Vitrified Brick
3 Layers Hydrex Felt cemented together with Hydrex Compound

ACID-PROOF FLOOR CONSTRUCTION.

"Over the cement motar surface shall be laid three layers of Hydrex felt bonded with Hydrex compound. The cement surface shall first be coated with a continuous and uniform layer of compound, to which it must adhere at every point. Where the felt is turned up on the walls and drain boxes an additional layer of felt and compound running parallel with the intersection of the two plane surfaces shall be applied.

"Over the completed acid-proof course shall be applied a layer of compound.

"Immediately after the acid-proofing is cool or soon enough after to insure against damage, the contractor shall spread a layer of cement mortar about 1½ in. thick over the entire horizontal area of the acid-proof course. This will form, after setting, a working surface on which the rest of the work shall be built."

After the protecting layer of cement mortar has set the specifications call for a course of concrete with a cement mortar finish and on top of this a second layer of acid-proofing consisting of two layers of the acid-resisting felt with three courses of the hot compound. Upon the top of this last acid-proofing course was laid bricks, the joints of which were filled with the hot compound as specified above.

It is interesting to note that the tests of the New York Edison Company have shown that the felt and compound used in this connection are not at all affected by sulphuric acid solutions.

An Improved Metallurgical Microscope.

By Wirt Tassin.

The value of metallographic methods in mill control has been recognized but the usefulness has been limited by the lack of portability in the appliances necessary for their use. This has made it difficult to study the forging, the casting or the bar as a whole, with the result that the metallographic field has to a large extent been limited to the examination of more or less small specimens cut from the piece and which may or may not be representative of the mass.

In June, 1910, I described in the *Iron Age* an illuminator which, attached to the metallographic microscope materially increased its compactness. I now propose to describe a com-

plete metallographic outfit which is light, compact, and portable and may be used either in the mill or in the laboratory and is equally serviceable for the study of the ingot, the forging, the bar, the casting or the small specimen, and which, it is believed, will meet the needs of the metallurgist, the engineer of tests, and the inspector.

The apparatus consists of a camera, microscope and illuminating device, all self-contained (Fig. 1).

The illuminating device consists of a tube which carries the lenses and is mounted in a sleeve provided with a set-screw to lock it in any position. Attached to this sleeve by means of a trunnion is a hanger. This is fastened by a set-screw to an arm which locks into the barrel of the microscope. The rear of the tube carries a shield which is provided with clips to hold the source of light when electricity is used and is slotted to hold a rod and lamp carrier when gas is used.

The source of light may be an acetylene jet or an electric lamp.

When acetylene is used the gas may be obtained from a generator or from a "Prestolite" tank. The lamp is a "Twentieth Century" jet, the support for which is held in a carrier made of two pieces of tubing brazed together at right angles. Each piece is provided with a set-screw so that the jet may be moved up or down, front or back, turned on its axis and set at any desired distance with reference to the plane of the lenses of the condensing train. The apparatus as arranged for illuminating with gas is shown in Fig. 2.

When electricity is used the lamp is carried in a socket fixed in an insulated metal hood. The whole is held in position with reference to the lenses of the condensing train by means of clips fastened to the shield. This arrangement provides for an up and down movement of the light. The apparatus as arranged for illuminating with electricity is shown in Fig. 1.

The current may be obtained from an accumulator or by cuting down the street supply. A convenient lamp bank to reduce street current for use with Mazda miniature lamps is wired as in Fig. 3. The lamp resistance needed with a 110-volt current is:

Two 32-cp and one 16-cp carbon lamps for a 6-volt, 16-cp Mazda miniature lamp.

One 32-cp and one 8-cp carbon lamp for an 8-cp Mazda miniature.

One 32-cp and one 4-cp carbon lamp for a 6-cp, 6-volt tungsten.

One 4-cp and one 16-cp carbon lamp for a 4-cp, 6-volt tungsten miniature lamp.

The lamp recommended is a 6-volt, 16-cp, headlight Mazda, No. 12 G., candelabra base.

The microscope consists of a barrel and draw tube mounted on a handle arm and provided with a coarse and fine adjustment, the latter of the lever type. Attached to the barrel just below the draw tube is a collar which holds a rod controlled by a set-screw. The base of this rod rests on the handle arm. The arrangement prevents the possibility of the coarse adjustment overhauling when the camera is in use. The base of the microscope is the stage. Through the center of this is a 1-in. circular opening which affords free space for the objective when examining large masses below the stage. Leveling screws are provided which permit of the adjustment of the apparatus perpendicular to nearly any surface. The advantages of this are to be seen in Fig. 1 where the microscope is shown mounted on a 6-in. shaft. Provision is made for the use of a detachable mechanical stage when needed.

The camera is attached to the barrel of the microscope by a tube which slips in and out like the draw tube and may be removed with the same ease. The whole moves with and becomes a part of the barrel so that any degree of focusing is possible. The distance between the eye piece and the ground glass is a constant, so that the amplification is a standard for all magnifications. The image is 3¼ in. in diameter and is formed on a 3½ x 3½-in. plate. The time required for the exposure is rarely over 10 seconds.

The apparatus packs in a space 12 x 12 x 5½ in. A suit case fitted with compartments to hold the various parts makes a very convenient container. One that measures 12 in. in width by 24 in. long by 6 in. deep, will hold the camera, the microscope and all its accessories, the lamp bank or an acetylene

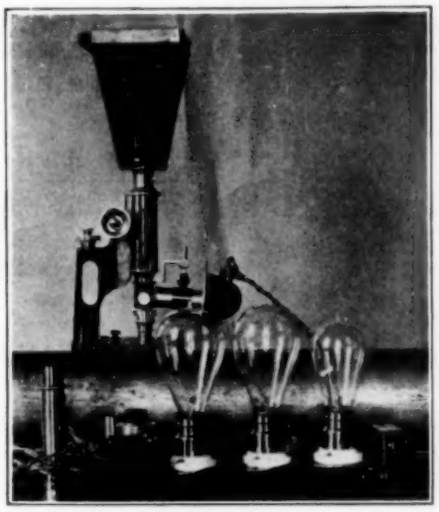


FIG. 1.—MICROSCOPE CAMERA, ILLUMINATING DEVICE AND LAMP BANK, AS USED WITH ELECTRIC LIGHT AND MOUNTED ON A CINCH SHAFT.

generator of the "Neverout" type, four plate holders, four boxes of plates, two tanks, one for developing and one for fixing, together with the chemicals necessary for etching and for developing. The suit case when fitted with a curtain also serves as a dark room.

In examining a large piece such as an engine frame the surface is "spot polished" in as many places as desired. A dam of modeling wax is then built around the spot to hold the etching medium and when the etching has been completed the dam is broken, the surface washed with water and gasoline and the

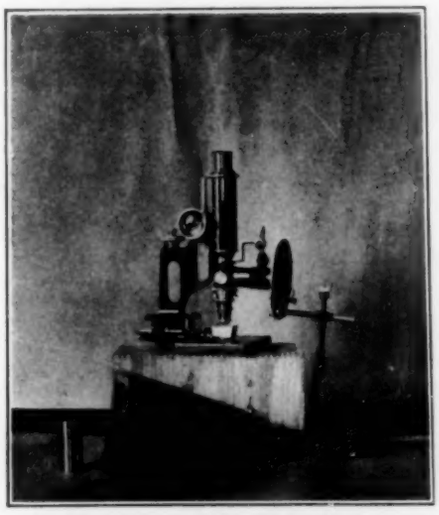


FIG. 2.—MICROSCOPE, CAMERA DETACHED WITH ACETYLENE LIGHT AND MECHANICAL STAGE

microscope adjusted and all is ready for the visual examination and the taking of a photographic record.

To polish, use is made of a portable ¼-hp motor with a flexible shaft. As it is almost impossible to hold a wheel steady in the hand to give a surface flat enough for a microscopic examination use is made of a steady rest somewhat like the "Old man" of a drill. This insures a uniform bearing for the grinding wheel and with the proper gradation of the abrasive a mirror polish is obtained without much difficulty. A 130 F. car-

borundum wheel is used for surface grinding and is followed by a set of buffs charged with flour emery paste, washed flour emery paste and gold rouge in the order given.

Arrangements are under way for the manufacture of the apparatus and when completed it may be secured from the Arthur

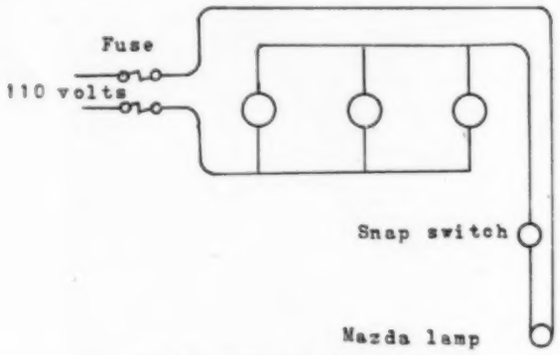


FIG. 3.—WIRING OF LAMP BANK.

H. Thomas Company, of Philadelphia, who are already prepared to furnish the illuminating device which may be attached to any microscope.

Washington, D. C.

Application of the Moore Filter to Rapid Filtration and Purification of Sewage.

In our December issue we mentioned a very successful exhibition given on November 20 of a new sewage purification process at the laboratory of the Moore Filter Company and Chemical Process Company in New York City, at which rep-

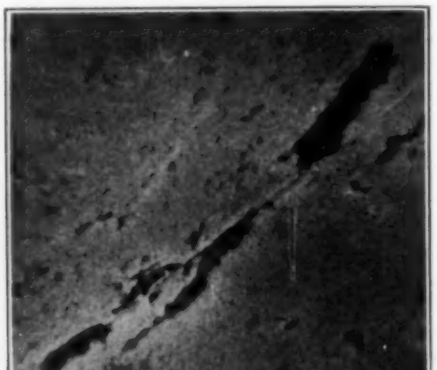


FIG. 4.—MANGANESE SULFIDE AND SLAG X 150 IN A MAN-HOLE COVER—TAKEN WITH THE APPARATUS.

resentatives of the water departments of various Eastern cities were present.

It is essentially an application of the well-known Moore vacuum filter to rapid sewage filtration. The chemical features of the process are the invention of Mr. James M. Neil. The rights to the patents are owned by The Chemical Process Company, 170 Broadway, New York City.

From a description of the process, given out by the company, we extract the following information. The system is called the M. S. D. & W. P. or Municipal Sewage Disposal and Water Purification System.

"The operation of the process requires the use of suction pumps, and vacuum filters whose surfaces are permeable to liquid and impermeable to solids. Movable vacuum filters are preferably used so that the separated solids can be removed from the sewage tanks at will.

"The flow of sewage to be treated is directed into a tank or other suitable receptacle, first passing it through a screen or screens in order to remove the floatage and other large bodies therefrom. In this tank suitable precipitants are added to the sewage (greatly in excess of the amount actually required for precipitation of the organic matters) and the whole intimately mixed by agitation, which may be effected by air, steam or water pressure, or by mechanical means, or by a combination of these forces. Such agitation and aeration are maintained continuously during the process, in order to break up and granulate the solids and to commingle the precipitable and fatty matters with the precipitant so as to render them in a condition amenable to collection on the filtering medium and to effect complete precipitation and final separation of the solids from the fluids in the manner hereinafter described.

"By employing an excess of precipitant in the treatment tank its effect is practically instantaneous while owing to the fact that no solids consisting of precipitant or solids in the sewage can escape through the filtering medium the consumption of precipitant is not greater than the amount actually required to effect complete precipitation of the organic and foreign matters contained in the mixture.

"The vacuum filter is placed in the treatment tank at a point preferably remote from the sewage inlet, and when it is submerged and suction begun a continuous flow of the agitated mixture is drawn toward the medium, on the surfaces of which the excess precipitant, precipitates and other solids in suspension in the mixture are deposited, while the liquid is drawn through the film or cake of precipitant and the filtering medium to the pump discharge.

"Complete precipitation and instantaneous separation of the purified fluid from the solids are thus effected.

"The operation may be continued until the deposit of solids becomes so thick on the filtering medium as to unduly interfere with the volume of liquid being drawn through it. This will be indicated by the vacuum gauge. The medium may then be raised from the sewage tank and moved to the dumping point, suction being maintained to hold the solids thereon during its removal, and in order to dry the solids, the medium may be held suspended in the air under suction as long as desired before dumping.

"When suction is stopped the cake of solids falls from the medium, or its removal from it may be assisted by a reverse current of air. After dumping the cake, the medium may be returned to the sewage tank, and the operation repeated indefinitely.

"Instead of raising and moving the medium every time it is loaded, the suction may be momentarily stopped and the solid matters thrown back into the mixture and again subjected to the forces of agitation in the tank—a reverse current of fluid or air may be used to assist in such throwing off.

"Suction being resumed again, the operation of loading is repeated, and when the surfaces of the medium are again sufficiently coated the solids may be again thrown back into the tank and these operations of loading and unloading may be repeated until it becomes desirable to remove some of the accumulated solids from the tank, which may be done in the manner already described.

"There being a continuous flow of sewage into the tank carrying valuable ingredients, this method of operation results in displacing the excess of precipitant from the cake with these ingredients. The cake may thus be finally recovered in a concentrated and highly desirable condition for subsequent treatment whereby the oils, greases, etc., may be liberated by any of the well-known methods and the residue used as a fertilizer.

"Several mediums may be used loading, drying and discharging alternately, so that the process may be carried on continuously. Extra tanks and mediums may be used when necessary to cope with a large or varying supply of sewage, the pump or pumps being always run at a capacity equivalent to the flow of sewage, and suitable precipitants added during the operation in sufficient quantities to deal with the amount and character of the sewage being treated.

"Heretofore in the art of treating sewage it has been found

necessary to use large quantities of hypochlorite or other germicides in order to destroy harmful bacteria. By this process harmful bacteria are almost entirely destroyed, so that in order to insure their complete destruction only a comparatively small amount of germicide need be used. This may be added to the mixture in agitation in the sewage tank, or it may be added to the effluent after it has been separated from the organic and solid matters.

"The results obtained by the above process and which have been effected without the use of a germicide are remarkable. Numerous tests of effluents obtained from samples of sewage originally rich in organic matter and harmful bacteria treated by the usual methods of precipitation and separation were found to be still high in organic matters, and dangerously high in harmful bacteria contents, while comparative tests of effluents obtained from the same sewage treated by this process showed them in every case to be entirely free from organic matters and harmful germs.

"Important features of the process are that it can be operated in open tanks without creating objectionable odors and at a minimum expense for labor."

At the exhibition of the process it was stated that the precipitant used in the process was simply waste material from paper mills, but that lime may be used instead.

PERSONAL.

Mr. **William F. Carroll,** formerly with the Compania Metalurgica Mexicana, at San Luis Potosi, has gone to Pachuca, Hidalgo, Mexico, for the Blaisdell Coscotitlan Syndicate.

Mr. **A. F. Flynt,** metallurgist, of Tepic, Mexico, has returned to the southern republic after an extended visit in the United States.

Mr. **R. W. French,** superintendent for the United States Refining & Reduction Company, at Florence, Colo., will spend the winter in Arizona.

Mr. **Robert W. Hunt,** consulting engineer, of Chicago, was awarded the John Fritz medal for 1912. This award is given "to commemorate notable scientific and industrial progress," and is made annually.

Dr. **Richard L. Moore,** physical chemist of the Bureau of Mines, is now stationed at the branch office, 502 Foster Bldg., Denver, Colo. Other members of the staff attached to the same office are **Karl L. Kithil,** mining technologist; **J. C. Roberts,** mining engineer in charge of the rescue car, and **John A. Davis,** mining engineer.

Mr. **J. Wilson Nevius,** representing the Los Angeles Chamber of Mines and Oil, has been making a study of the bag-house system of fume control at the smelter of the Mammoth Copper Mining Company, Kennett, Cal.

Dr. Jos. W. Richards, of Lehigh University, sailed with Mrs. Richards on December 21 for Jamaica, for a few weeks' vacation.

Mr. **B. Viola,** formerly managing and chief engineer of Charles Pfizer & Co., has opened a consulting engineer's office at 140 Liberty Street, New York City, for the installation and equipment of chemical and allied industrial works and power plants.

Mr. David White has been appointed chief geologist of the U. S. Geological Survey, vice **Waldemar Lindgren,** resigned. Mr. White has been in the Survey since 1886, and has had charge of several departments of the work. Dr. **F. L. Ransome** will succeed to the duties of Mr. Lindgren, in the economic geology of metalliferous deposits. Mr. Lindgren will be retained by the Survey for special work in a study of the Homestake mine, South Dakota, and at other places in Arizona.

Mr. **C. E. Whittlesey,** treasurer of the McGraw Publishing Company, celebrated his seventieth birthday on December 14, 1912. On this occasion he was entertained at luncheon at the Engineers' Club by his fellow directors of the McGraw Publishing Company and was presented with a silver salver as "a tribute of esteem and affection." Wr. Whittlesey, besides being the treasurer of the McGraw Publishing Company, has been the treasurer of the Electrochemical Publishing Company, the former publisher of METALLURGICAL AND CHEMICAL ENGINEERING, from its early days. All the members of the staff of this journal are indebted to Mr. Whittlesey for innumerable kind words and acts of advice and encouragement, and join his many other friends in extending to him their most cordial wishes.

Digest of Electrochemical U. S. Patents.

Prior to 1903.

Arranged according to subject-matter and in chronological order.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyears, National Union Building, Washington, D. C.

ORE TREATMENT (*Continued*).

629,685, July 25, 1899, Carl Hoepfner, of Berlin, Germany.

Relates to a process for electrodepositing zinc or other metals in solution by using an insoluble anode or an anode of a metal electronegative to that to be deposited, preferably lead, copper or mercury or the compounds of such metals, such as the sulfid or an argentiferous sulfid of lead, the silver, etc., remaining undissolved as a sludge. These compounds are either cast into bars, etc., or may be placed in a wire basket holder, etc. The anodes should preferably be kept in motion. The cathodes, which are also kept in motion, consist of carbon or of the metal to be deposited. The apparatus consists of a series of U-shaped frames bolted together and separated by diaphragms, forming separate cells, alternate cells constituting anode cells, and the intermediate ones the cathode cells; communication between like cells is established by passages in the walls of the frames. The anode electrolyte is an acid in which the anode metal is soluble or a salt containing such acid as its radicle. The cathode electrolyte is any solution containing the metal to be deposited, such as zinc, iron, nickel, copper, etc. Both electrolytes are preferably heated and kept in constant circulation through the cell. The lead or other metal dissolved from the anode is precipitated outside of the cell as an insoluble compound, from which the metal may be reduced by smelting. The solution of the metal as anode will generate an electromotive force and to that extent reduce the electromotive force ordinarily applied to the cell.

629,686, July 25, 1899, Carl Hoepfner, of Frankfort-on-the-Main, Germany.

Relates to the extraction of zinc or zinc and other metals from ores of the Brokenhill type and also of the Leadville, Colo., type. Refers to his patent No. 664,269. The process consists in reacting upon a crude zinciferous sulfid mineral containing also other metals, as lead and silver, with a suitable chlorid solution, as cupric or perchlorid of iron, extracting a portion of the lead, removing the solution and roasting the undissolved residue; reacting upon this residue with hydrochloric acid gas in the presence of water or a chlorid solution from a prior treatment, dissolving first the lead and silver and finally obtaining a solution of zinc chlorid, which is electrolyzed first with a low electromotive force to remove the electronegative metals present, gradually raising the electromotive force to successively precipitate the intermediate metals and finally precipitating the zinc; the electrolyte may now be used in the hydrochloric acid gas extraction.

631,040, August 15, 1899, John E. Greenawalt, of Denver, Colo., assignor of one-half to William Robinson, of same place.

Relates to the extraction of gold or gold and silver from their ores. The ore is crushed to 20 to 30 mesh and subjected to a chloridizing roasting, after which it is placed in a vat having a bottom made of slats covered with a perforated board; above the board is placed a gravel bed, the coarser stones at the bottom and smaller ones at the top. Upon the small stones is placed the ore. A leaching solution consisting of a nearly saturated solution of sodium chlorid with some bromine is

electrolyzed in the anode compartment of a cell, producing free chlorin and hypochlorous acid and free bromine. This solution is used to leach the ore and is then passed through an electrodepositing cell using lead cathodes with a current density of about 0.07 amp per square foot of cathode surface.

633,544, Sept. 19, 1899, Harry S. Badger, of Denver, Colo., assignor of one-half to Charles W. Caryl, of same place.

Relates to apparatus for extracting and amalgamating precious metals. A suitable tank is provided with a central hollow vertical shaft having hollow horizontal cross-arms at the bottom thereof, the cross-arms carrying hollow stirrers with openings at the bottom. The vertical shaft is arranged to be rotated, is connected to a supply of compressed air and is connected so that the horizontal cross-arm is the anode. On the bottom of the tank is a copper plate flooded with mercury, connected as cathode. The pulverized ore is added to a solution of cyanide of potassium and such other reagents as facilitate the dissolving of the precious metals. The rotating stirrers and compressed air keep the ore in a state of suspension and leave the mercury free for the amalgamation and electrodeposition of precious metal.

639,579, Dec. 19, 1899, John Jones, of East Melbourne, Victoria.

Relates to the recovery of zinc from its ores. The ore is first roasted to sulfate, sulfite or oxid, leached by water or acid and the solution obtained freed from iron and other impurities, which is effected by flowing the solution down through absorbing towers through which is passed upward a stream of ammonia-containing producer gas, which operation is regulated so that the zinc remains in solution while the iron, etc., is precipitated. The purified solution is then acidified with sulfuric acid in a separate vessel and again passed through an absorbing tower through which is passing additional ammonia-containing producer gas. The purified producer gas may be used for fuel, etc. The zinc-sulfate ammonia-sulfate solution is passed into the anode compartment of an electrolytic cell, while an acidified zinc-sulfate ammonium-sulfate solution passes into the cathode compartment. In order to prevent the catholyte from becoming neutral or alkaline it is constantly acidified either by free acid or by circulating the anolyte through the cathode compartment. Any manganese salts in the solution are precipitated in the anode compartment by a suitable reducing agent.

639,766, Dec. 26, 1899, Lewis E. Porter, of Los Angeles, Cal.

Relates to rotary amalgamating barrels for extracting precious metal from base ores. The rotary barrel has an amalgamating cathode lining, either of removable plate, or by first copper-plating the inside, and then amalgamating. Adjacent the cathode is a diaphragm lining of burlap, etc., secured between a double layer of wooden slats. The anode consists of a series of carbon plates supported upon spiders, and are concentric within and rotate with the barrel. An adjustable valve, adapted to be automatically opened as the barrel rotates, affords an exit for any excess of gas pressure generated during the operation. The pulp mixed with the desired chemicals is fed into and removed from the space within the diaphragm through a removable closure in the end of the barrel; during the operation, compressed air is forced into the barrel through a hollow shaft, the air assisting in forcing the liquid through the diaphragm, and of acting as an oxidizing agent. Refers to a co-pending application filed Aug. 18, 1896.

640,717, Jan. 2, 1900, Charles P. Tatro and George Delius, of Seattle, Wash., assignors to Harry S. Sharpe, of same place.

Relates to an apparatus for extracting precious metals from ores. The apparatus comprises a tank having a rotary drum supported on a shaft within the tank; a series of fixed carbon bars serving as an anode around the drum, a rotary stirrer within the tank below the anode, and a conical bottom containing mercury to amalgamate any large pieces of gold, etc., that may be in the ore. The pulp, mixed with a suitable solvent, is fed into the tank, the drum rotated and current turned on. The rotating stirrer keeps the ore in suspension, while the dissolved metals are electrodeposited upon the drum, from which they are removed by a scraper pressing against the upper surface. After the operation is completed, the pulp and mercury are removed, the mercury is then retorted or otherwise treated to remove any precious metal. Refers to a co-pending application (patent 640,718) for the process.

640,718, Jan. 2, 1900, Charles P. Tatro and George Delius, of Seattle, Wash., assignors to Harry S. Sharpe, of same place.

Relates to a process for extracting precious metals from ores. Refers to a co-pending application (patent 640,717) for the apparatus used. The ores are pulverized to pass an 80-mesh sieve, the pulp mixed with a bath comprising an aqueous solution of common salt, and such reagents, as lime, to precipitate the baser metals, such as iron, while leaving the precious metals in the solution. With some ores, an acid bath is first used to dissolve a particular base metal, which is then precipitated by an alkali. A small per cent of bromine may be added to facilitate the solution of the gold. The precious metal is electrolyzed and recovered as described under patent 640,717.

641,571, Jan. 16, 1900, Wilhelm Witter, of Hamburg, Germany.

Relates to the production of a solution of cyanogen halide, such as chloride or bromide, for the extraction of precious metals from their ores. A solution containing an alkali halide, such as chloride or bromide, an alkali cyanide, and a magnesium salt, is electrolyzed in a cell without a diaphragm and with inert electrodes, such as carbon. The solution produced contains cyanogen halide. The following equation expresses the reaction:

$$2NaCl + MgSO_4 + KCN + 2H_2O = ClCN + KCl + Na_2SO_4 + H_2 + Mg(OH)_2.$$

The magnesium salt and alkali cyanide are used in excess of the molecular proportions. The reaction may be carried out in the leaching vat direct in the presence of pulverized ore.

643,096, Feb. 6, 1900, Samuel B. Christy, Berkeley, Cal.

Relates to the electrolytic precipitation of gold and silver from the large volumes of dilute solutions of alkaline cyanides resulting from the cyanide extraction of gold and silver ores, etc. Uses a tank containing a large number of removable electrodes; the tops of the anodes remain about an inch below the solution level, and divide the tank into a number of separate compartments; between the anodes are the cathodes which project above the solution level, but leave a space of about an inch between them and the bottom of the tank. The liquid is electrolyzed while flowing through the tank, between the electrodes, above the anodes and below the cathodes; the deposit upon a number of cathodes being subsequently redissolved as an anode in a smaller cell, and deposited upon a single smaller cathode, thereby reducing the quantity of base metal to be separated from the gold.

649,151, May 8, 1900, William Wright, New York, N. Y., assignor by mesne assignements, of eleven-twentieths to William Bouldin, trustee, of Orange, N. J.

Relates to an apparatus for extracting metals from refractory ores, and comprises a leaching tank having a perforated false bottom, a filtering medium over the perforated bottom, a cathode within the space below the false bottom, a plurality of stationary pins arranged in concentric circles projecting upwardly from the false bottom, a rotatable shaft supporting radial cross-arms from which carbon anodes are suspended and arranged in concentric circles intermeshing the upwardly projecting pins. In operation, about 2000 lb. of ore are mixed with 1200 lb. of water containing from 20 to 40 lb. of common salt. The rotation of the anodes keeps the mass in constant agitation, the current liberating chlorine and decomposing the ore, the metals dissolved being deposited upon the cathode beneath the false bottom.

650,646, May 29, 1900, Frederic H. Long, Chicago, Ill., assignor to Ross J. Beatty, trustee, Muncie, Ind.

Relates to an apparatus for electrolytically treating ores, and comprises mixing, reducing, and filtering tanks; within the former the pulp is thoroughly mixed to a sludge with the electrolyte; the mixture is then transferred to the reducing tank, which consists of a circular vertical tank containing an upper

anode compartment and a lower cathode compartment, separated by a cone-shaped filter; centrally within the tank and communicating with the anode compartment is an upright penstock containing a reciprocating piston, which causes a circulation of the sludge through the anode compartment and penstock. During this circulation the ore passes the anode and is subjected to the action of the chlorine there liberated, whereby the metals are dissolved and then electrolytically deposited upon the cathode, which may be mercury. The base metals in the anode liquors may be precipitated as hydroxides by lime. Any gases liberated are fed into the mixer, where they assist in dissolving the metallic content of the ores. After the treatment, the sludge is transferred to the filter in which the liquid is separated for re-use or recovery of any remaining metallic salts.

BOOK REVIEWS.

The Principles of Applied Electro-Chemistry. By **A. J. Allman,** D.Sc. 5½ x 8½ inches (14 x 21½ cm.), 547 pages, 136 illustrations; price $5.00. New York: Longmans, Green & Co. London: Edward Arnold.

A volume designed for students and technical men. Assuming an elementary knowledge of chemistry and electricity, Part I, 192 pages, treats of the fundamental phenomena and theory of electrochemistry, particularly of aqueous solutions. Part II treats of the various technical processes, from the standpoint of showing the close connection between theory and practice, treating the material critically, and excluding mere "paper" processes.

The author has succeeded in producing a valuable book; comprehensive, clear, fair and making full use of the copious electrochemical literature to date. To give a catalog of the subjects treated is unnecessary; it covers practically the entire field of inorganic electrochemistry. Organic electrochemistry is not included.

We commend the book as valuable to students and technical men. It is the equivalent of Haber's *"Grundriss der technischen Elektrochemie,"* in English, revised to date, and improved upon.

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Cyanide Practice. By **H. W. MacFarren.** 8vo (15½x23½ cm.), 291 pages, 32 illustrations; price $3.00 net. New York: McGraw-Hill Book Company.

The basic idea of this book is not to treat exhaustively every detail of the cyanide process, but to give a bird's-eye view of the whole field, explaining clearly the principles involved in each step and giving sufficient detailed information to illustrate the principles. Description of variations of details at different plants is not attempted. The object thus in view is to bring the student or practitioner to the point of understanding thoroughly the process as a whole, and of being prepared to study more *in extenso* any branch of the process. To assist in the latter a very complete bibliography (of English literature only), covering 55 pages and divided into 33 heads, gives abundant information. It is a carefully prepared book and accomplishes its avowed object.

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Per-Acids and Their Salts. By T. Slater Price, D.Sc. Six by 9 in. (15x22½ cm.), 123 pages; price $1.00 net. New York and London: Longmans, Green & Company.

This is the second of the Munographs on Inorganic and Physical Chemistry, which Dr. A. Findlay is doing the great service of editing and publishing. Modern scientific literature really needs only two classes of books: brief syllabi of an entire science, setting forth clearly principles and describing their application in the fewest possible words and comprehensive monographs going into great detail on the various branches of the science. Such must be the program of future scientific literature; the day of the vast encyclopedia of science which covers in one work all science or all of a science in all its details is rapidly passing.

The present book is a good illustration; it gives more precise, detailed, satisfactory information about per-acids and their salts than can be found anywhere else. Just as we go to an expert oculist or dentist for advice about eyes or teeth so must we turn to just such books as this for the best information about a special subject in science.

Dr. Price has done his work well; one has only to read a little in it, anywhere, to get that feeling of satisfaction which comes from the realization that the author knows all about all he is discussing. "May his tribe increase."

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Theoretical and Physical Chemistry. By **S. Lawrence Bigelow,** Professor of General and Physical Chemistry, University of Michigan. Octavo (14x21.5 cm.), 544 pages, 80 illustrations; price $3.00. New York: The Century Company.

Intended to lead third-year students in college or university to "a critical consideration of these half-learned, three-quarters forgotten, fundamental principles"; and recommended as following first courses in general chemistry and qualitative analysis. The author very concisely divides the book into four parts: "The first section (three chapters) aims to show the value of philosophy in science. In the second section (seven chapters) the ever-present question is: What are the ultimate constituents? In the third section (nine chapters) we are, primarily studying the properties of substances as such. In the last section (eleven chapters) attention is centered upon the processes by which substances become what they are."

The book is written with great care, clearness and insight. It is just the kind of text-book that would engage and hold the student's attention. To one not a student it appears in places to lack candor; that is, not to get down close enough to simple reasoning from observed facts, and at others to state conclusions on insufficient evidence. In all teaching conclusions should be given their exact values, and never overdrawn; thus, only are students taught exact thinking and reasoning. However, this book is above the average in these respects.

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Church's Laboratory Guide. Revised and largely re-written by **Edward Kinch,** formerly Professor of Chemistry, Imperial College of Agriculture, Tokio. Ninth edition, 12mo (12x19 cm.), 368 pages, 44 illustrations; price $2.50 net. New York: D. Van Nostrand Company.

This is a complete course in chemical laboratory practice for agricultural students. Part I comprises 39 lessons in elementary chemical manipulation and experimenting, chosen with discrimination and excellently presented. Part II is a short course in qualitative analysis, also well compiled and written, but necessarily very brief. Part III introduces the student to quantitative analysis, and after a short introduction takes up at some length the analysis of manures, soils, waters and foods. For the student in an agricultural college who does not intend to become an agricultural chemist, the book appears a most excellent laboratory manual; the agricultural chemist, however, should lay broader foundations in both qualitatitve and quantitative analysis than are to be gotten from this book.

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General and Industrial Inorganic Chemistry. By Dr. **Ettore Molinari.** Translated from third Italian edition by Dr. **E. Feilmann.** Large octavo (15x25½ cm.), 704 pages, 283 illustrations; price $6.00 net. Philadelphia: P. Blakiston's Son & Company.

The author is professor of industrial chemistry in Milan, and has written this treatise for the use of students in order to bring before them the applications of chemical principles in industry simultaneously with the comprehensive study of the principles themselves. He assumes some knowledge of the elementary facts of chemistry and physics, but gives in the first 125 pages his own summary of chemical and physical principles. This is commendable, because it forms a connecting link with the students' preparatory studies, and further teaches him the author's point of view of these elementary

laws. Then the author proceeds systematically with the preparation in the laboratory and the manufacture on a large scale of the various non-metallic and metallic elements and compounds.

A distinguishing feature of the treatment is the setting forth, as clearly as possible, of the commercial side, including prices, statistics and commercial considerations. This is intended to give the student the business side of industrial chemistry, so that when entering the industry he may not be ignorant of the elementary financial foundations of manufacturing chemistry as a business and of the values and prices of the materials he uses and produces. It will make an excellent up-to-date text-book for students in chemical engineering.

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Lead Poisoning and Lead Absorption. By **Thomas H. Legge,** M.D., and **Kenneth W. Goadby.** 8vo (15x21½ cm.), 308 pages, 15 illustrations; price, $3.50 net. New York: Longmans, Green & Co. London: Edward Arnold.

The senior author is government medical inspector of factories in England; the junior author is surgeon to smelting and white-lead factories in London. The work covers the symptoms, pathology and prevention of lead poisoning, with special reference to its industrial origin and the processes involving this risk. The inhalation of lead dust is cited as the main cause, and exhaust fans, hoods or vacuum cleaners are named as the simple means by which the dust can be removed and the worker's health assured. The work is written in a highly scientific and exact style, using accurate medical phraseology. This makes it very satisfactory as a medical monograph, but limits its usefulness as respects the general reader. Every manager of works manufacturing lead products should be provided with the book, study its statements and follow its recommendations.

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La Cementazione dell 'Acciaio. By Dott. **Federico Giolitti,** Professor of Metallurgy in the Royal Polytecnicum of Turin. Octavo, 16x25 cm., 506 pages, 155 illustrations. Turin: Unione Tipografico-Editrice Torinese.

This brilliant Italian savant left the University of Rome two years ago to build and assume charge of the finest metallurgical laboratory in Italy, at the Polytechnic of Turin. The above work may be regarded as the first fruits of his labors and those of his students in this new chair.

There exists in no other literature so complete and masterly a study of the cementation process of manufacturing steel. It bears throughout the personal imprint of the enthusiastic investigator and able writer. Visiting his laboratory in Rome three years ago, we were wonderfully impressed by his enormous activity and the wonderful program of matters to be studied out when he should get into his new laboratory at Turin. Fortunate, indeed, is Italy in having such a professor and doubly fortunate those Italian students who have the inspiration of working under him.

As for the program of the book, 250 pages, divided into five chapters, deal with research into the chemistry of cementation. The contents of these chapters are: Early researches; up to the end of the XIXth century; the first seven years of the XXth century; the last five years; actual state of our present knowledge. In this section the author relates at length his own exhaustive investigations on the chemistry of the process, much of the information being here published for the first time.

In the second half of the book the industrial applications of the cementation process are discussed in a similarly thorough manner. The five chapters deal with: Total transformation into hard steel; partial transformation into hard steel (case-hardening), sub-divided into treatment by solids, liquids, gases, mixed agents and special agents; thermal treatment of cemented products; methods of control of the cementation; contents of patents on cementation. In this part the furnaces are illustrated by photographs and working drawings, and the author gives details of practice in various countries—American practice being well described.

We congratulate the indefatigable and genial author and also his country on such a fine contribution to scientific literature and progress. Surely this is a victory of peace.

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Coal: Its Composition, Analysis, Utilization and Valuation. By **E. E. Somermeier,** Professor of Metallurgy, Ohio State University. Octavo, 15½ x 23 cm., 175 pages, 8 illustrations. Price $2.00. New York: McGraw-Hill Book Company.

The book has been prepared for the mechanical and power-plant engineer, the chemical engineer and chemist, and business men and operators buying and selling coal. The author has met this rather difficult program in a satisfactory manner.

The chemical part has particularly attracted our attention, by its very clear exposition of chemical principles and details involved in the analysis and combustion of coal, including a number of new and original points of view and calculations. There are full detailed directions for sampling, getting heat-values in calorimeters, analyzing flue-gases and interpreting the experimental results. The chapter on purchase specifications is short and condensed, but practical; it might have been amplified. About 300 analyses of coals, with calorimetric values, form a useful appendix. It is a well-written, useful and timely book.

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Engineering and Metallurgical Books, 1907-1911. By **R. A. Peddie.** 206 pages, 4¾x7¼; $1.50 net. New York: D. Van Nostrand Company.

A bibliography or catalog of the engineering and metallurgical books published in the years 1907 to 1911 inclusive. The books are classified under subjects, and a brief characterization corresponding to a sub-title is generally given. The names of both the American and English publishers are included and the prices in both British and American currency.

Apparently the work has been done with thoroughness and care, and will make a useful reference catalog for engineers and librarians.

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Centenary Celebration of the First Commercial Gas Company. Lectures delivered at the Franklin Institute, Philadelphia, April 18 and 19, 1912. Octavo, illustrated; 174 pages. New York: The American Gas Institute, New York.

This book contains five carefully prepared lectures: By-Products in Gas Manufacture, by Prof. Charles E. Munroe; Commercial and Financial Aspects of the Gas Industry, by Hon. George B. Cortelyou; The Technique of Gas Manufacture, by Alfred E. Forstall, M.E.; Gas as an Illuminant, by Van Rensselaer Lansingh; The Use of Gas for Heat and Power and the Testing of Gas, by E. B. Rosa, Ph.D. Besides these first-class lectures there is a chronology of the use of gas, covering several pages, and description of an interesting Loan Exhibition.

The book is an appropriate and valuable souvenir of a dignified and memorable celebration.

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Hygiene for the Worker. By **Wm. H. Tolman,** Ph.D., and **Adelaide W. Guthrie.** 12mo (12x18.5 cm.), 231 pages, numerous illustrations; price 50 cents. New York: American Book Company.

This inexpensive book is one of the Hygiene Series, edited by C. Ward Crampton. The authors are the Director of the American Museum of Safety and an assistant in the research department of that museum. It is intended for students in vocational, industrial and manual training schools and particularly for night schools.

An inspection of the nineteen chapters shows them to be carefully, accurately and attractively written, full of good common sense as well as of scientifically accurate information.

It is a good book to give to any worker, but particularly to the young; employers of labor may also find profit in reading it.